50/-

THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1909

FOUNDED BY RICHARD P. ROTHWELL

EDITED BY

WALTER RENTON INGALLS

Editor of the Engineering and Mining Journal; Member American Institute of Mining Engineers; Member Institution of Mining and Metallurgy; Member Mining and Metallurgical Society of America; Member American Institute of Chemical Engineers; Member Society of Chemical Industry, Etc.

VOLUME XVIII

SUPPLEMENTING VOLUMES I TO XVII

PUBLISHED BY

THE ENGINEERING AND MINING JOURNAL

McGRAW-HILL BOOK COMPANY

SOLE SELLING AGENTS

239 WEST 39TH STREET, NEW YORK

1910

Hill Publishing Company, New York, U. S. A.

CONTRIBUTORS TO VOLUME XVII

AGUIRRE-ACHA, J.
Consul-General of Bolivia, New York.
Tin Mining in Bolivia.

AINSWORTH, SAMUEL
Lyons, Kan.
Salt in Kansas.

ATKINSON, T. R.
State Engineer and Ex-officio Mine Inspector, Bismarck, N. D.
Coal Mining in North Dakota.

ATWATER, C. G.
Engineer, United Coke and Gas Company, New York.
Ammonia and Ammonium Sulphate.

AUSTIN, L. S.
Consulting Metallurgical Engineer, Salt Lake City, Utah.
The Metallurgy of Copper in 1909.

BARBOUR, E. H.
State Geologist, Lincoln, Neb.
Cement in Nebraska.
Coal Mining in Nebraska.

BARBOUR, PERCY E.
Mining Engineer, Salt Lake City, Utah.
Gold in Utah.
Lead in Utah.

BARTHOLOMAEUS, GEORGE
Secretary, Bureau of Mines and Mines Inspection, Jefferson City, Mo.
Coal Mining in Missouri.

BLAKE, WILLIAM P.
Late Territorial Geologist of Arizona.
Gold in Arizona.

BLATCHLEY, RAYMOND S.
Assistant Geologist, State Geological Survey, Urbana, Ill.
Petroleum in Illinois.

BOWNOCKER, J. A.
State Geologist, Columbus, O.
Coal Mining in Ohio.
Gypsum in Ohio.
Natural Gas in Ohio.
Petroleum in Ohio.

BRENDEL, H.
Muzquiz, Coahuila, Mexico.
Coal Mining in Mexico.

CARY, W. P.
Mining Engineer, Butte, Mont.
Coal Mining in Montana.
Gold in Montana.

COLCORD, F. F.
Assistant Manager, U. S. Metals Refining Co., New York.
Sampling and Assaying.

COLLINS, GEORGE E.
Mining Engineer, Denver, Colo.
Copper in Colorado.
Gold in Colorado.
Lead in Colorado.

DEWOLF, F. W.
Acting Director, State Geological Survey, Urbana, Ill.
Coal Mining in Illinois.

DORR, J. V. N.
Metallurgical Engineer, Denver, Colo.
Gold in South Dakota.

DOUGLAS, JAMES
President, Phelps, Dodge & Co., New York.
Copper in Arizona.

DOUGLAS, JAMES
Chief State Mine Inspector, Hartford, Ark.
Coal Mining in Arkansas.

FAY, ALBERT H.
Editorial Staff, *Engineering and Mining Journal.*
Barytes.

FERGUSON, H. G.
Division of Geology and Mines, Manila, P. I.
Gold in the Philippines.

FLEMING, W. L.
Formerly on Editorial Staff of the *Engineering and Mining Journal.*
Tungsten.

FOHS, F. JULIUS
Assistant Geologist, Geological Survey, Lexington, Ky.
Fluorspar.

FRIEDMAN, L. W.
Correspondent of the *Engineering and Mining Journal*, Birmingham, Ala.
Alabama Coal Market.
Alabama Iron Market.

FULTON, CHARLES H.
President, State School of Mines, Rapid City, S. D.
Cyanidation during 1909.

GEORGE, HAROLD C.
Director, Wisconsin State Mining Trade School, Platteville, Wis.
Petroleum in the Appalachian Field.
Petroleum in Indiana and Ohio.

GIBSON, THOMAS W.
Deputy Minister of Mines, Toronto, Ont.
Nickel and Cobalt in Ontario.
Silver in Ontario.

HARRISON, GEORGE
Chief Inspector of Mines, Columbus, O.
Coal Mining in Ohio.

HAVARD, F. T.
Assistant Professor of Mining and Metallurgy, University of Wisconsin, Madison, Wis.
Antimony.

HAWORTH, ERASMUS
State Geologist, Lawrence, Kan.
Natural Gas in Kansas and Oklahoma.
Petroleum in Kansas and Oklahoma.

HOBART, FREDERICK
Associate Editor of the *Engineering and Mining Journal.*
Iron and Steel.

HOFMAN, H. O.
Professor of Metallurgy, Massachusetts Institute of Technology, Boston, Mass.
Recent Improvements in Lead Smelting.

HORE, R. E.
School of Mines, Houghton, Mich.
Cobalt District in 1909.

HORTON, FREDERICK W.
Assistant Editor of "The Mineral Industry."
Arsenic.
Asbestos.
Bauxite.
Borax.
Chromium and Chrome Ore.
Feldspar.
Graphite.
Nickel.
Petroleum.
Phosphate Rock.
Potassium Salts.

HOWE, HENRY M.
Professor of Metallurgy, Columbia University, New York.
The Treatment of Steel in Electric Furnaces.

INGALLS, W. R.
Editor of the *Engineering and Mining Journal,*
Copper.
Lead.
Zinc.

JACOBS, E.
Correspondent of the *Engineering and Mining Journal,* Victoria, B. C.
Coal Mining in British Columbia.
Copper in British Columbia.
Gold and Silver in British Columbia.
Lead in British Columbia.

JONES, JOHN D.
Chief Mine Inspector, Denver, Colo.
Coal Mining in Colorado.

JUDD, E. K.
Instructor in Mining, Columbia University, New York.
Gold and Silver.
Manganese.
Mica.

KENNEDY, J. E.
Correspondent of the *Engineering and Mining Journal,* Platteville, Wis.
Zinc Mining in Wisconsin.

KÜMMEL, H. B.
State Geologist, Trenton, N. J.
Cement in New Jersey.
Copper in New Jersey.
Iron Ore in New Jersey.

LATOUCHE, T. D.
Superintendent, Geological Survey of India, Calcutta, India.
Lead in Burma.

LEES, JAMES H.
Assistant State Geologist, Des Moines, Ia.
Coal Mining in Iowa.

LEONARD, A. G.
State Geologist, Grand Forks, N. D.
Coal Mining in North Dakota.

LOCKE, CHARLES E.
Professor of Mining, Massachusetts Institute of Technology, Boston, Mass.
Progress in Gold Milling in 1909.
Progress in Ore Dressing and Coal Washing in 1909.

LUTY, B. E. V.
Correspondent of the *Engineering and Mining Journal,* Pittsburg, Penn.
Pittsburg Coal Market.
Pittsburg Iron and Steel Market.

MCCALLIE, S. W.
State Geologist, Atlanta, Ga.
Bauxite in Georgia.
Iron Ore in Georgia.

Mance, F. S.
Dept. of Mines, Sydney, New South Wales.
Coal Mining in Australia.
Copper in Australasia.
Gold and Silver in Australasia.
Tin in Australia.
Zinc in Australasia.

Memminger, C. G.
Mining Engineer, Lakeland, Fla.
Phosphate Mining in Florida.

Moore, F. Cushing
State Mine Inspector, Boise, Idaho.
Coal Mining in Idaho.
Copper in Idaho.
Gold in Idaho.
Lead in Idaho.
Phosphate Rock in Idaho.

Morrison, E.
Correspondent of the *Engineering and Mining Journal*, Chicago, Ill.
Chicago Coal Market.
Chicago Iron and Steel Market.

Newland, David H.
Assistant State Geologist, Albany, N. Y.
Cement in New York.
Feldspar in New York.
Garnet in New York.
Graphite in New York.
Gypsum in New York.
Salt in New York.
Talc in New York.

Norwood, C. J.
State Geologist, Lexington, Ky.
Coal Mining in Kentucky.

Parsons, Floyd W.
Associate Editor, *Engineering and Mining Journal.*
Coal and Coke.

Payne, Henry M.
Mining Engineer, Morgantown, W. Va.
Coal Mining in Alabama.

Peters, E. D.
Professor of Metallurgy, Harvard University, Cambridge, Mass.
A Study of Practicable Copper Slags.

Phillips, William B.
Director, Bureau of Economic Geology, Austin, Tex.
Coal Mining in Texas.

Read, T. T.
Professor of Mining and Metallurgy, Pei-Yang University, Tientsin, China.
Antimony in China.
Arsenic in China.
Cement in China.
Coal Mining in China.
Copper in China.
Gold and Lead in China.
Quicksilver in China.
Silver in China.
Tin in China.
Zinc in China.

Richards, Joseph W.
Professor of Metallurgy, Lehigh University, So. Bethlehem, Penn.
The Metallurgy and Uses of Aluminum in 1909.

Richards, Robert H.
Professor of Mining and Metallurgy, Massachusetts Institute of Technology, Boston, Mass.
Progress in Gold Milling in 1909.
Progress in Ore Dressing and Coal Washing in 1909.

Rogovin, I. I.
Mining Engineer, St. Petersburg, Russia.
Platinum in Russia.

Ruhm, H. D.
President, Niagara Alkali Co., Niagara Falls, N. Y.
Phosphate Rock in Tennessee.

Sellards, E. H.
State Geologist, Tallahassee, Fla.
Fuller's Earth in Florida.
Phosphate Mining in Florida.

Smith, R. V.
Professor of Mining Engineering, School of Mines, Socorro, N. M.
Copper in New Mexico.
Gold in New Mexico.
Iron Ore in New Mexico.
Lead in New Mexico.

Smyth, Henry Lloyd
Professor of Mining and Metallurgy, Harvard University, Cambridge, Mass.
Notes on the Practice in Mining.

Speier, Paul
Metal Merchant, Breslau, Germany.
German Spelter Trade in 1909.

Thomas, Kirby
Associate Editor, *Engineering and Mining Journal*, New York.
Bismuth.
Manganese in Mexico.
Nickel and Cobalt in Mexico.
Quicksilver in Mexico.
Sulphur Deposits of Louisiana and Texas, Geology of.
Sulphur in Mexico.
Vanadium in Mexico.

Turner, H. W.
Mining Engineer, San Francisco, Cal.
Quicksilver in California.

TYSSOWSKI, JOHN
Editorial Staff, *Engineering and Mining Journal.*
Sulphur and Pyrites.

VAIL, RICHARD H.
Assistant Editor, *Engineering and Mining Journal.*
Talc and Soapstone.

WALCH, E.
Correspondent of the *Engineering and Mining Journal*, Paris, France.
Coal Mining in China.

WHEELER, H. A.
Mining Engineer, St. Louis, Mo.
Lead in Southeast Missouri.

WHITE, I. C.
State Geologist, Morgantown, W. Va.
Coal Mining in West Virginia.
Natural Gas in West Virginia.
Petroleum in West Virginia.

WILKINSON, W. FISCHER
Principal of the Cornwall School of Metalliferous Mining, Camborne, Cornwall.
Gold Mining in Rhodesia in 1909.
Gold Mining in the Transvaal in 1909.
Gold Mining in West Africa, Gold Coast and Ashanti in 1909.

WOODBRIDGE, DWIGHT E.
Mining Engineer, Duluth, Minn.
Iron Ore in Lake Superior Region.

YOUNG, C. M.
Mining Engineer, Lawrence, Kan.
Salt in Kansas.

ZOOK, JESSE A.
Statistician, Joplin, Mo.
Zinc Mining in Missouri and Kansas.

THE STATE GEOLOGICAL SURVEYS.

Of the 46 States of the Union, 35 have organized geological surveys, these comprising nearly all of the States in which the mining industry is important. The organization of a geological survey in Massachusetts is under consideration. Certain States which have no geological survey have officials who give attention to the mining industry. Thus, California has a State mineralogist, while Idaho has a State mine inspector who collects statistics of mineral production. The States having organized geological surveys, together with the names and addresses of the respective State geologists, as of Jan. 1, 1910, are given in the following list:

STATE GEOLOGISTS.

State.	Name and Address.	State.	Name and Address.
Alabama	Eugene A. Smith, University	New Jersey	H. B. Kümmel, Trenton
Arizona	....	New York	John M. Clark, Albany
Arkansas	A. H. Purdue, Fayetteville	N. Carolina	Joseph Hyde Pratt, Chapel Hill
Connecticut	Wm. N. Rice, Hartford	N. Dakota	A. G. Leonard, Grand Forks
Colorado	R. D. George, Boulder	Ohio	J. A. Bownocker, Columbus
Florida	E. H. Sellards, Tallahassee	Oklahoma	Charles N. Gould, Norman
Georgia	S. W. McCallie, Atlanta	Pennsylvania	Richard R. Rice, Beaver
Illinois	F. W. DeWolf, Acting Director, Urbana	S. Carolina	Earle C. Sloan, Charleston
Indiana	W. S. Blatchley, Indianapolis	S. Dakota	E. C. Perisho, Vermillion
Iowa	Samuel Calvin, Des Moines	Tennessee	George H. Ashley, Nashville
Kentucky	C. J. Norwood, Lexington	Texas	W. B. Phillips, Austin
Kansas	Erasmus Haworth, Lawrence	Vermont	G. H. Perkins, Burlington
Maine	L. A. Lee, Brunswick	Virginia	Thos. L. Watson, Charlottesville
Maryland	William Bullock Clark, Baltimore	Washington	Henry Landes, Seattle
Michigan	R. C. Allen, Lansing	West Virginia	I. C. White, Morgantown
Mississippi	E. H. Lowe, Jackson	Wisconsin	E. A. Birge, Madison
Missouri	H. A. Buehler, Rolla	Wyoming	Edwin Hall, Cheyenne
Nebraska	E. H. Barbour, Lincoln		

STATE MINE INSPECTORS, COMMISSIONERS, ETC.

State.	Name and Address.
Arkansas	G. B. Tucker, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock
California	L. E. Aubury, State Mineralogist, San Francisco
Colorado	T. J. Dalzell, Commissioner of Mines, Denver
Idaho	F. Cushing Moore, State Mine Inspector, Boise
Michigan	J. L. Nankervis, Commissioner of Mineral Statistics, Calumet
Missouri	George Bartholomaeus, Secretary, Bureau of Mines and Mines Inspection, Jefferson City
Montana	William Walsh, State Mine Inspector, Helena
New Mexico	J. E. Sheridan, Mine Inspector for the Territory of N. M., Silver City
Ohio	George Harrison, Chief Inspector of Mines, Columbus
Pennsylvania	James Roderick, Chief, Department of Mines, Harrisburg
South Dakota	Nicholas Treweek, Jr., State Mine Inspector, Lead
Tennessee	R. A. Shiflett, State Mine Inspector, Nashville
West Virginia	John Laing, Chief, Department of Mines, Charleston

VALUES OF FOREIGN COINS.

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1910.

COUNTRY.	Standard	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Argentine Republic	Gold	Peso	$0.965	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions.
Austria-Hungary	Gold	Crown	.203	Gold: 10 and 20 crowns. Silver: 1 and 5 crowns.
Belgium	Gold	Franc	.193	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Silver	Boliviano	.389	Silver: boliviano and divisions.
Brazil	Gold	Milreis	.546	Gold: 5, 10, and 20 milreis. Silver: ½, 1, and 2 milreis.
British Possessions, N. A. (except Newf'nd).	Gold	Dollar	1.000	
Central Amer. States—				
Costa Rica	Gold	Colon	.465	Gold: 2, 5, 10, and 20 colons ($9.307). Silver: 5, 10 25, and 50 centimos.
British Honduras	Gold	Dollar	1.000	
Guatemala, Honduras, Nicaragua, Salvador	Silver	Peso	.375	Silver: peso and divisions.
Chile	Gold	Peso	.365	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions.
China	Silver	Tael. Amoy	.615	
		Tael. Canton	.613	
		Tael. Cheefoo	.588	
		Tael. Chin Kiang	.601	
		Tael. Fuchau	.569	
		Tael. Haikwan (customs)	.626	
		Tael. Hankow	.575	
		Tael. Kiaochow	.596	
		Tael. Nankin	.609	
		Tael. Niuchwang	.577	
		Tael. Ningpo	.591	
		Tael. Peking	.599	
		Tael. Shanghai	.562	
		Tael. Swatow	.568	
		Tael. Takau	.619	
		Tael. Tientsin	.596	
		Dollar. Hongkong	.404	
		Dollar. British	.404	
		Dollar. Mexican	.407	
Colombia	Gold	Dollar	1.000	Gold: condor ($9.647) and double condor. Silver: peso.
Denmark	Gold	Crown	.268	Gold: 10 and 20 crowns.
Ecuador	Gold	Sucre	.487	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.
Egypt	Gold	Pound (100 piasters)	4.943	Gold: pound (100 piasters), 5, 10, 20, and 50 piasters. Silver: 1, 2, 5, 10, and 20 piasters.
Finland	Gold	Mark	.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France	Gold	Franc	.193	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
German Empire	Gold	Mark	.238	Gold: 5, 10, and 20 marks.
Great Britain	Gold	Pound sterling	4.866½	Gold: sovereign (pound sterling) and ½ sovereign.
Greece	Gold	Drachma	.193	Gold: 5, 10, 20, 50, and 100 drachmas. Silver: 5 drachmas.
Haiti	Gold	Gourde	.965	Gold: 1, 2, 5, and 10 gourdes. Silver: gourde and divisions.
India (British)	Gold	Pound sterling*	4.866½	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy	Gold	Lira	.193	Gold: 5, 10, 20, 50, and 100 lire. Silver: 5 lire.
Japan	Gold	Yen	.498	Gold: 5, 10, and 20 yen. Silver: 10, 20, and 50 sen.

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1910.

* The sovereign is the standard coin of India, but the rupee ($0.3244½) is the current coin, valued at 15 to the sovereign.

COUNTRY.	Standard	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Liberia	Gold	Dollar	1.000	
Mexico	Gold	Peso†	.498	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions.
Netherlands	Gold	Florin	.402	Gold: 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold	Dollar	1.014	Gold: 2 dollars ($2.027).
Norway	Gold	Crown	.268	Gold: 10 and 20 crowns.
Panama	Gold	Balboa	1.000	Gold: 1, 2½, 5, 10, and 20 balboas. Silver: peso and divisions.
Persia	Silver	Kran	.069	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2, and 5 krans.
Peru	Gold	Libra	4.866½	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands	Gold	Peso	.500	Silver peso: 10, 20, and 50 centavos.
Portugal	Gold	Milreis	1.080	Gold: 1, 2, 5, and 10 milreis.
Russia	Gold	Ruble	.515	Gold: 5, 7½, 10, and 15 rubles. Silver: 5, 10, 15, 20, 25, 50, and 100 copecks.
Spain	Gold	Peseta	.193	Gold: 25 pesetas. Silver: 5 pesetas.
Straits Settlements	Gold	Pound sterling§	4.866½	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold	Crown	.268	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	.193	Gold: 5, 10, 20, 50, and 100 francs. Silver: 5 francs.
Turkey	Gold	Piaster	.044	Gold: 25, 50, 100, 250, and 500 piasters.
Uruguay	Gold	Peso	1.034	Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	.193	Gold: 5, 10, 20, 50, and 100 bolivars. Silver: 5 bolivars.

† Seventy-five centigrams fine gold.
‡ Value in Mexico, $0.498.
§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given tentative value of $0.567758½.

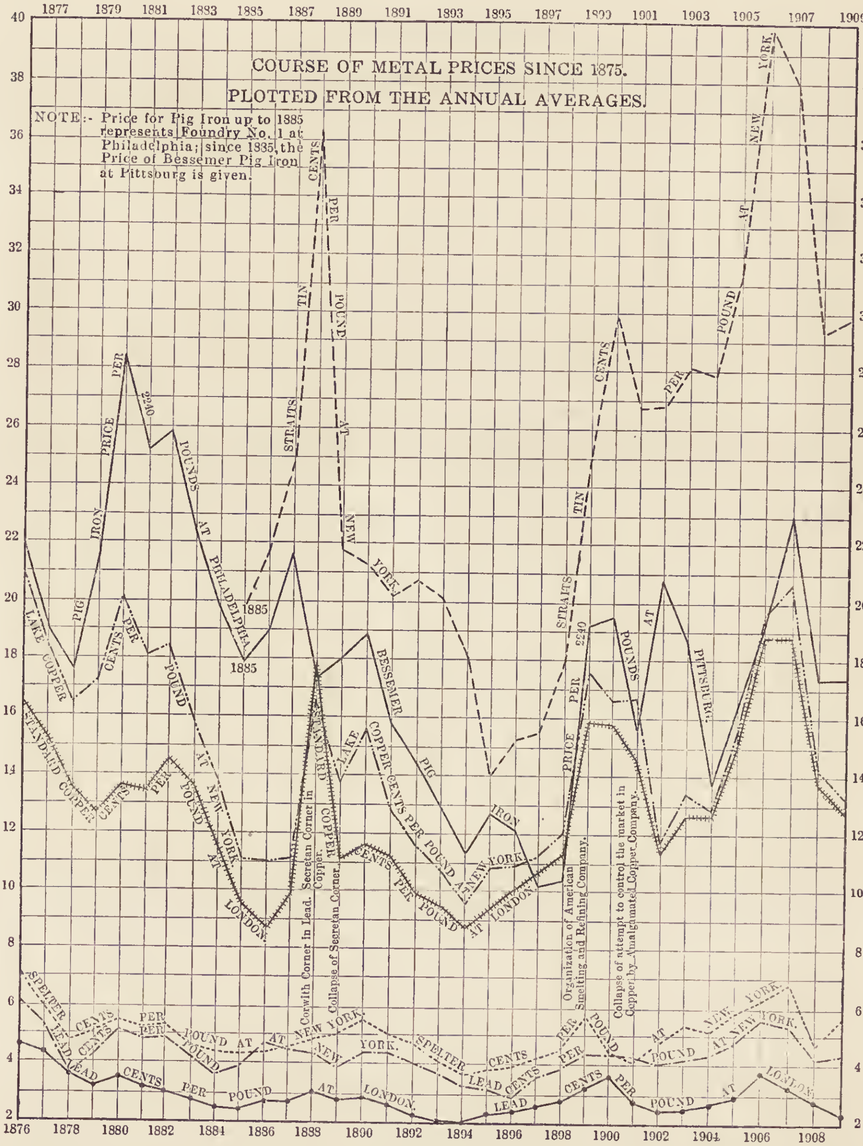
CONTENTS OF VOLUME XVIII.

INTRODUCTION.

In the preparation of the statistics for this volume, the figures previously reported for 1908, and in some cases for earlier years, have been revised in the light of later and more minute investigation, in accordance with our regular practice; therefore it is important for all who have occasion to refer to them to observe the caution to use always the figures in the latest volume of THE MINERAL INDUSTRY. There are no statistical reports of this nature that are absolutely correct, owing to the practical impossibility of obtaining accurate data from all the producers in some extensive and greatly subdivided industries, the absence of records on the part of many producers, which prevents them from making returns, the unwillingness of a few to give their figures, and the confusion as to the stage in which many products are to be reported. The last difficulty is especially likely to lead to errors in values, some producers estimating the worth of their product at the pit's mouth, and others reporting it in a more or less advanced state of completion, including thus not only the cost of carriage, but also the cost of manipulation. These difficulties appear not only in our statistics, but also in those reported by various governments. In our own work we make a practice of going backward and correcting figures previously reported, whenever mistakes are discovered by subsequent investigation. In estimating values, we are disposed to use actual market prices rather than the prices reported by the producers themselves, which are apt to be misleading for the reasons mentioned above.

For many of the statistics relating to the mineral production of the United States in 1909 and previous years, we are indebted to the U. S. Geological Survey; for the production of gold and silver in the United States to A. P. Andrew, director of the mint, and for the statistics of American imports and exports to O. P. Austin, chief of the bureau of statistics of the Department of Commerce and Labor. Acknowledgment is due also to various State geological surveys and statistical bureaus for information incorporated in this volume. In the text and footnotes to the various tables, we have generally credited such information to the proper sources, but this acknowledgment may stand for any unintentional oversight. The same acknowledgment is due with respect to the foreign statistics, which we state generally as officially reported by the respective governments, when such reports are available.

It has been impossible to collect statistics for all substances of mineral production in the United States, but the omissions are generally in



the cases of those of minor importance. In many instances it has been possible to make use of the statistics collected by the U. S. Geological Survey for substances whereof an independent investigation in behalf of

PRODUCTION OF METALS IN THE UNITED STATES. (x)

Products.	Measures.	1908 Quantity.	1908 Value.	1909 Quantity.	1909 Value.
Aluminum	lb.	13,000,000	$4,095,000	15,000,000	$3,345,000
Antimony	lb.	6,914,000	553,406	6,556,000	422,277
Copper	lb.	948,196,490	127,058,329	1,105,336,326	145,451,207
Ferromanganese (q)	Lg. T.	152,018	6,460,765	225,040	9,885,000
Gold fine	Troy oz.	4,574,746	94,560,000	4,800,783	99,232,200
Iron, pig	Lg. T.	15,784,000	267,540,378	25,570,431	439,290,000
Lead	Sh. T.	318,876	26,785,584	369,164	31,548,755
Nickel	lb.	(e)500,000	250,000	(e) 500,000	250,000
Platinum	Troy oz.	750	14,350	750	18,653
Quicksilver	Flasks (o)	20,147	903,391	20,592	953,410
Silver, fine	Troy oz.	52,440,800	27,722,304	53,849,000	27,733,312
Sodium	Sh. T.	(e)2,000	1,000,000	(e)2,000	1,000,000
Tin	Sh. T.	(v) 1,200	707,160	(w)	....
Zinc (y)	Sh. T.	210,511	19,897,500	266,462	29,326,808

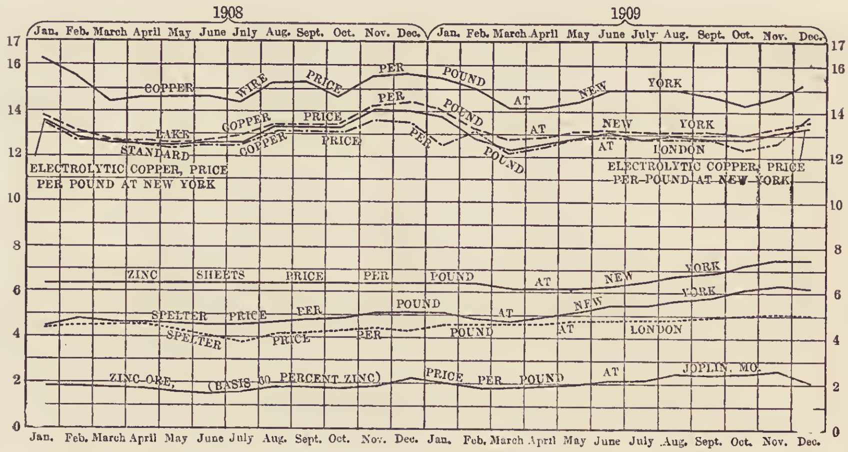
Additional details will be found under the respective captions farther on in this volume. (e) Estimated. (o) Flasks of 75lb. (q) Includes spiegeleisen, although the value is given as for ferromanganese. (v) Recovered from scrap metal. (w) Statistics not available. (x) Includes only metal produced from domestic ores except in case of zinc. (y) Includes zinc from foreign ore.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES.

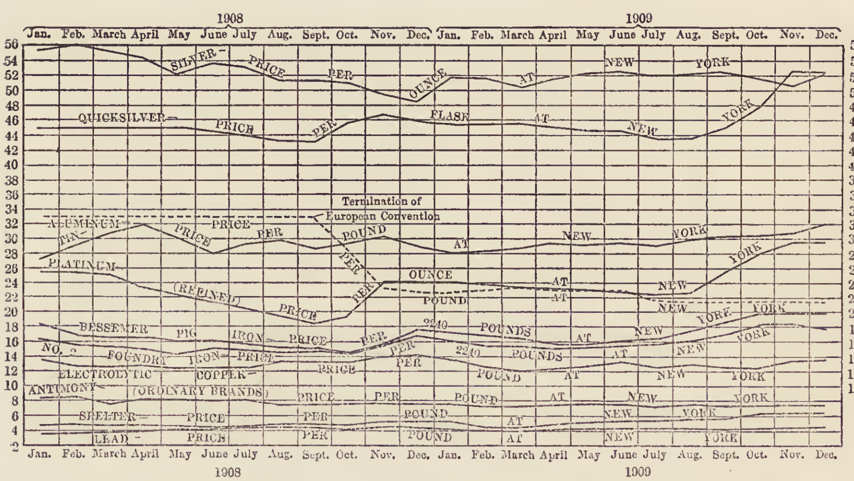
Products.	Measures.	1908 Quantity.	1908 Value.	1909 Quantity.	1909 Value.
Antimony ore	Sh. T.	360	$19,800	95	$4,700
Asbestos	Sh. T.	1,350	24,000	4,025	87,625
Asphaltum	Sh. T.	185,352	1,888,881	(w)	....
Barytes	Sh. T.	38,546	130,409	39,831	138,634
Bauxite	Lg. T.	(u) 52,167	263,968	90,325	475,110
Borax	Sh. T.	22,200	1,117,000	16,629	1,163,960
Chrome ore	Lg. T.	280	5,600	205	4,100
Coal, anthracite	Sh. T.	80,329,578	159,122,961	77,126,980	152,781,217
Coal, bituminous	Sh. T.	326,411,903	375,890,003	367,076,821	427,903,323
Emery	Sh. T.	790	10,360	1,230	16,510
Feldspar	Sh. T.	67,240	400,918	73,090	398,340
Flint	Sh. T.	64,220	318,000	(e) 52,420	286,700
Fluorspar	Sh. T.	38,795	225,998	50,843	103,704
Fuller's earth	Sh. T.	30,517	270,685	29,561	289,000
Garnet	Sh. T.	2,530	78,090	3,802	121,700
Graphite, amorphous	Sh. T.	1,821	8,230	1,703	14,528
Graphite, crystalline	lb.	3,433,039	149,763	5,669,899	340,194
Gypsum	Sh. T.	(u) 1,721,829	4,138,560	(w)	....
Iron ore	Lg. T	33,780,987	60,821,976	53,086,869	95,556,364
Limestone flux	Lg. T.	9,563,158	4,720,485	(e) 14,516,000	6,956,000
Magnesite	Sh. T.	8,967	52,342	7,942	62,588
Manganese ore (d)	Lg. T.	6,344	64,659	(w)	....
Mica sheet	lb.	(u) 972,964	234,021	(e) 888,000	213,000
Mica scrap	Sh. T.	(u) 2,417	33,904	(e) 2,670	37,400
Molybdenum ore	Sh. T.	15	6,000	*Nil.*	....
Monazite	lb.	(u) 422,646	50,718	(u) 541,931	65,032
Petroleum, crude	Bbl. (i)	180,673,241	131,891,466	180,908,696	114,390,000
Phosphate rock	Lg. T.	2,375,031	15,040,882	2,184,399	9,649,868
Pumice	Sh. T.	(u) 10,569	39,287	(e) 20,000	90,000
Pyrite	Lg. T.	206,471	744,463	210,000..	756,814..
Salt	Bbl. (k)	(u) 28,745,319	7,486,894	(w)	....
Sand, glass	Sh. T.	(u) 1,093,553	1,134,599	(u) 1,104,451	1,163,375
Sulphur	Lg. T.	307,761	6,795,363	303,000..	6,666,000..
Talc, ordinary ground and soapstone	Sh. T.	(u) 46,615	703,832	(e) 61,000	854,000
Talc, fibrous	Sh. T.	70,739	697,390	(e) 65,000	617,500
Tin ore	Sh. T.	50	12,500	*Nil.*	....
Tungsten ore	Sh. T.	497	126,281	1,607	559,500
Zinc ore	Sh. T.	838,377	....	1,027,984	....

Additional details will be found under the respective captions farther on in this volume. (d) Does not include manganiferous iron ore. (e) Estimated. (i) Barrels of 42 gallons. (k) Includes salt used in manufacture of alkali; the barrel of salt weighs 280 lb. (u) Figures reported by the United States Geological Survey. (w) Statistics not yet available.

THE MINERAL INDUSTRY was not made. Many of the statistics of the United States Geological Survey are now published with commendable promptness and with an accuracy that makes it unnecessary to enter



COURSE OF METAL PRICES IN 1908 AND 1909, PLOTTED FROM THE MONTHLY AVERAGES.



COURSE OF METAL PRICES IN 1908 AND 1909, PLOTTED FROM THE MONTHLY AVERAGES.

into the same duplication as formerly. The statistics for foreign countries are given in all cases for the latest year available. In several cases our work has been greatly facilitated by the courtesy of the statisticians of foreign governments in sending us their reports for 1909 in manu-

PRODUCTION OF SECONDARY MINERALS AND CHEMICALS IN THE UNITED STATES.

Products.	Measures.	1908		1909	
		Quantity.	Value.	Quantity.	Value.
Alundum	lb	3,160,000	$189,600	13,578,000	$814,860
Ammonium sulphate	Sh. T.	83,400	5,085,660	106,500	5,968,260
Arsenic	lb.	2,603,505	99,193	2,015,880	57,957
Bromine	lb.	1,149,000	103,410	1,110,000	110,000
Carborundum	lb.	4,907,170	294,430	6,478,290	388,697
Cement, natural hydraulic	Bbl. (g)	(u)1,686,682	834,509	1,500,000	675,000
Cement, portland	Bbl. (h)	(u)51,072,612	43,547,679	61,300,000	52,105,000
Cement, puzzolan	Bbl. (t)	(u)151,451	95,468	160,646	99,453
Coke	Sh. T.	23,028,649	55,890,681	35,076,902	81,638,058
Copper sulphate (c)	lb.	37,654,961	1,833,796	45,000,000	1,900,360
Copperas	Sh. T.	35,334	388,674	42,225	464,475
Crushed steel	lb.	630,000	44,100	818,000	57,260
Graphite, artificial	lb.	7,385,511	502,667	6,870,529	467,196
Lead, white	Sh. T.	116,628	10,515,315	131,643	12,652,638
Lead, sublimed, white	Sh. T.	9,100	973,000	(w)	(w)
Lead, red	Sh. T.	11,358	1,156,282	15,805	1,438,197
Lead, orange mineral	Sh. T.	393	43,157	530	68,003
Litharge	Sh. T.	12,254	1,231,206	13,391	1,266,903
Mineral, wool	Sh. T.	9,197	77,228	11,626	101,621

Additional details will be found under the respective captions farther on in this volume. (c) Does not include sulphate made from metallic copper. (e) Estimated. (g) Barrels of 265 lb. (h) Barrels of 380 lb. (t) Barrels of 330lb. (u) Figures reported by the United States Geological Survey. (w) Statistics not yet available.

script in advance of the regular publication in print. This has been highly helpful in enabling us to present this complete summary of 1909 during the year following. Some of the statistics reported in this volume are preliminary, and subject to revision. It is our belief, however, that statistics of reasonable commercial accuracy, promptly published, are of greater value to technology and trade than are statistics, correct to the last unit, which are published a year or two late.

The list of contributors to Vol. XVIII is noteworthy for its length and the high standing of all. The reviews of industrial progress are uniformly prepared by recognized experts in each line, while the records of current events are supplied by thoroughly informed reporters. Thus, the progress in the mining industry of each mineral is to a large extent described by the State geologists, or members of the State geological surveys, nearly all of whom are contributors to Vol. XVIII, as they were to Vol. XVII. These contributors give an official character to the publication, which constitutes a valuable and appreciated medium for collating and bringing to general attention the statistical researches and commercial investigations in the several States. This is work that is most properly done by the State geological surveys, and The Mineral Industry affords them a means for the coördinated presentation of reports that otherwise might remain buried in local libraries.

AVERAGE MONTHLY PRICES OF CHEMICALS, EARTHS, MINERALS, ETC., IN 1909

(IN CARLOAD LOTS AT NEW YORK)

Material.	Unit.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average 1909.	Average 1908.
Abrasives:															
Corundum, f.o.b. Niagara Falls, pow	C. per lb.	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	7.00
Emery, Turkish flour, in kegs	C. per lb.	2.125	2.125	2.125	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.939	1.75
Emery, Naxas flour	C. per lb.	2.125	2.125	2.125	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.875	1.939	1.75
Emery, Chester flour	C. per lb.	1.50	1.50	1.50	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.688	1.50
Emery, Peekskill flour, f.o.b. Easton, Pa	C. per lb.	1.375	1.375	1.375	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.469	1.25
Garnet	$ per Sh. T.	30.00	30.00	30.00	30.00	30.00	30.000	30.00	30.00	30.00	30.00	30.00	30.00	30.000	30.00
Boric acid	C. per lb.	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.000	7.00
Borax, sacks	C. per lb.	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.375	4.723	4.25
Alum, lump	$ per 100 lb.	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Aluminum sulphate, com'l	$ per lb.	1.425	1.425	1.56	1.625	1.625	1.625	1.625	1.625	1.625	1.625	1.625	1.625	1.585	1.11
Ammonium sulphate	$ per 100 lb.	3.075	3.075	3.025	3.025	2.90	2.875	2.875	2.825	2.6475	2.625	2.625	2.625	2.845	3.07
Arsenic, white, spot	C. per lb.	3.25	3.195	3.125	2.907	2.912	2.907	3.187	3.042	2.875	2.725	2.739	2.739	2.97	3.81
Barytes, American ground	$ per Sh. T.	16.50	16.50	16.50	14.50	14.50	14.50	14.50	14.50	14.50	13.50	13.50	13.50	14.75	17.06
Chrome ore, New Caledonia, 50 per cent. ex. ship N. Y.	$ per Lg. T.	18.75	18.75	18.75	18.75	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	16.24	17.50
Cobalt oxide	$ per lb.	2.025	2.025	1.30	1.30	1.30	1.30	1.30	1.40	1.425	1.425	1.425	0.825	1.42	1.61
Copperas, bulk	C. per 100 lb.	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
Fluorspar, lump	$ per Lg. T.	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Fullers' earth, lump	C. per 100 lb.	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	82.50	80.00
Magnesite, Greece, crude, 95 per cent	$ per Lg. T.	9.00	9.00	8.00	8.00	8.00	7.75	8.00	8.00	8.00	8.00	8.00	8.00	8.15	9.00
Magnesite, calcined, powdered	$ per Sh T	30.50	30.50	30.50	32.50	32.50	32.50	31.50	31.50	31.50	31.50	31.50	31.50	31.50	32.75
Gilsonite, Utah ordinary	$ per Lg. T.	32.00	32.00	32.00	32.00	32.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	34.34	33.58
Litharge, Am. powdered	C. per lb.	6.875	6.25	5.875	6.00	5.875	5.875	5.875	5.875	5.875	5.875	5.875	6.000	6.010	6.17
Red lead, American	C. per lb.	6.875	6.625	6.625	6.250	6.250	6.250	6.250	6.250	6.250	6.250	6.250	6.375	6.380	6.52
White lead, Am. dry	C. per lb.	5.437	5.437	5.437	5.625	5.625	5.625	5.625	5.5625	5.5625	5.5625	5.5625	5.5625	5.50	5.52
Nitrate of soda, 95 per cent. spot	$ per 100 lb.	2.175	2.175	2.15	2.148	2.17	2.20	2.15	2.125	2.10	2.10	2.087	2.0875	2.139	2.25
Zinc white, Am. extra dry	C. per lb.	5.375	5.375	5.375	5.375	5.375	5.375	5.375	5.375	5.375	5.375	5.375	5.4375	5.380	5.13
Phosphate rock:															
*Florida hard, 77 per cent	$ per Lg. T.	8.75	8.75	8.75	8.75	7.75	7.00	7.00	7.00	7.75	7.75	7.75	7.75	7.887	10.00
Florida land pebble, 68 per cent	$ per Lg. T.	4.125	4.125	4.125	3.875	3.875	3.875	3.875	3.875	3.875	3.875	3.875	3.875	3.937	4.42
†Tennessee, 78 to 80 per cent	$ per Lg. T.	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	6.42
Tennessee, 75 per cent	$ per Lg. T.	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	4.875	5.15
Tennessee, 68 to 72 per cent	$ per Lg. T.	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.31
‡South Carolina land rock, 60 per cent	$ per Lg. T.	7.125	7.125	7.125	7.125	3.750	3.750	3.750	3.750	3.750	3.750	3.750	3.750	4.875	6.17
Potassium cyanide, 98 and 99 per cent., 5 ton lots	C. per lb.	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50
Kainit, bulk	$ per Lg. T.	8.25	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.475	8.50
Pyrites:															
Dom., non-arsenical furnace, f.o.b. mines		11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
Dom., non-arsenical fines, f.o.b. mines		10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25
Imp., non-arsenical furnace	C. per Unit	12.50	12.50	12.125	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.29	12.71
Imp., arsenical furnace	S. per L.T.	12.00	12.00	11.875	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.79	12.21
Imp., arsenical fines		8.75	8.75	8.75	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	8.93	8.75
Imp., non-arsenical fines		10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75	10.75
Soda, caustic, 76/60	$ per 100 lb.	1.80	1.80	1.80	‡‡1.95	1.95	1.95	1.95	1.95	1.875	1.90	1.90	1.90	1.895	1.80
Saltcake, bulk	C. per 100 lb.	40.00	40.00	40.00	45.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	60.00	42.08	42.50
Sodium bromide	C. per lb.	13.50	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	19.46	15.30
Sodium cyanide, 120-130 per cent. KCN per 100 per cent., 5-ton lots	C. per lb.	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50
Sodium sulphate, com'l calcined	C. per 100 lb.	75.00	75.00	75.00	75.00	70.00	70.00	70.00	70.00	70.00	75.00	75.00	75.00	72.93	60.00
Sulphur:															
Louisiana, prime to New York	$ per Lg. T	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.08
Talc, domestic	$ per Sh. T.	20.00	20.00	20.00	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	16.00	18.00	20.00
Zinc chloride, gran	C. per lb.	4.625	4.625	4.625	5.50	5.50	5.50	5.50	5.50	4.50	4.50	4.50	4.50	4.948	4.75
Zinc dust	C. per lb.	5.0625	5.0625	5.0625	5.0625	5.0625	5.0625	5.375	5.825	6.375	6.75	6.75	6.75	5.683	5.23
Zinc sulphate	C. per lb.	2.125	2.125	2.375	2.75	2.75	2.375	2.375	2.375	2.375	2.375	2.375	2.25	2.385	2.16
Copper sulphate, carload lots	C. per lb.	4.750	4.700	4.600	4.600	4.324	4.240	4.225	4.225	4.175	3.980	3.9625	4.05	4.319	4.86

*F.o.b. Florida or Georgia ports. †F.o.b. Mt. Pleasant. ‡On vessel, Ashley river, S. C. ‡‡78/60 grade quoted hereafter.

NOTE—These quotations were for ordinary wholesale lots at New York unless otherwise specified and were generally subject to the usual trade discounts. In the case of some of the important minerals such as pyrites, sulphur, etc., in which there are well established markets the quotations fully represent the latter. But in the cases of some of the minor mineral products, the quotations represent what dealers asked of consumers and not what producers realized in selling their outputs as matter of private contract. The monthly figures are the averages of the quotations published in the JOURNAL, except the quotations for white arsenic, copper sulphate and nitrate of soda which are averages of weekly quotations.

Metallurgical Production—Prices—Consumption.

The statistics presented in the preceding tables cover, with but few exceptions, only the production of metals from domestic ore. In addition thereto, the United States produces a large amount of several metals derived from foreign ores, especially copper, lead, spelter, nickel, antimony, and the three precious metals—gold, silver, and platinum. Aside from gold and silver, data as to the total metallurgical production will be found in the following pages.

In the following pages also will be found much data as to the domestic consumption of metals and mineral substances. In general this figure is computed from the production plus imports, less exports; but in some important cases it has been possible to take into account the stocks on hand at the beginning and end of the year. In the cases of lead and spelter a statistical investigation, covering a series of years, has been made on the basis of reports received directly from the consumers.

In each chapter of this book all available information as to market conditions and prices has been given. For all of the important metals averages, monthly or annual, are given for a long series of years. Unfortunately, such data are not available for all of the mineral substances. The monthly averages for many of these substances in 1909, not including the metals, are given in the table on a preceding page.

CHRONOLOGY OF MINING IN NORTH AMERICA IN 1909.

Jan. 1—General strike of miners in New Zealand and at Broken Hill, N. S. W.

Jan. 6—Tennessee Steel Company incorporated in Maine with $20,000,000 capital stock.

Jan. 8—Concentrator of Arizona Copper Company, Clifton, destroyed by fire.

• Jan. 10—Explosion in Leiter mine, Zeigler, Ill., killed 27 men.

Jan. 12—Organization of Copper Producers' Association to report monthly production and stock of refined copper.—Explosion at Lick Branch colliery at Switchback, W. Va., killed 65 men.—Goldfield Consolidated mill began dropping 100 stamps.

Jan. 14—Gas and dust explosion at Aika colliery, Veszprem, Hungary, killed 56 men.

Jan. 19—U. S. Circuit Court of Appeals decided that zinc ore was not dutiable under the Dingley Act.

Jan. 22—The President, in a message to Congress, recommended that the coal, oil, gas and phosphate rights still remaining with the Government be withdrawn from entry and leased under conditions favorable for economic development.—Flood on the Rand, Transvaal, broke dam and flooded a mine, drowning 160 miners.—Kelvin-Calumet copper properties acquired by Ray Consolidated Company.

Jan. 24—Judge Hunt, in the Federal Court, Helena, Mont., refused the injunction asked for by the farmers in the Washoe smelter fume case.—Mines at Globe, Ariz., shut down because of labor agitation.

Jan. 27—Explosion in Merchants coal mine of the United Coal Company, Boswell, Penn., killed five men.

Jan. 28—Copper River railroad, Alaska, completed from Cordova to Abercrombie rapids.

Jan. 29—Resumption of work at Globe, Ariz.

Feb. 2—Explosion in Short Creek coal mine of Birmingham Coal and Iron Company, killed 17 men.

Feb. 11—Marianna coal mine resumed operations.

Feb. 15—First steel made at Gary, Ind

Feb. 16—Explosion in West Stanley coal mine, Durham, England, killed 120 men.

Feb. 19—U. S. Steel Corporation declared open market for steel products. Heavy cut in prices of steel.—Judge Hunt, United States Court of Montana, denied injunction to ranchers to stop dumping of tailings in creek by Butte companies.

Feb. 24—Annual meeting of A. I. M. E. opened at New Haven, Conn.—Rolling mills at Gary, Ind., finished their first rails.

Feb. 26—Settlement of dispute between Calumet & Hecla and Osceola announced.

March 2—Explosion at Colliery No. 14, Pennsylvania Coal Company, Port Blanchard, Penn., killed six men.

March 8—The United States lost its suit against the Standard Oil Company in the case of the $29,000,000 fine.

March 11—The Utah legislature passed a bill giving smelters right of eminent domain in counties of less than 20,000 population.

March 12—Crow's Nest Pass Coal Company passed into the control of the Great Northern Railroad Company and the Granby Consolidated Copper Company.

March 16—Consolidated Coal Company, of Maryland, declared a 60 per cent. stock dividend.

March 18—Receiver appointed for the Idaho Smelting and Refining Company.

March 20—Explosion at Sunnyside Coal Mine, Ill., caused by a windy shot, killed five men.

March 24—A joint meeting of the Mining, Civil, Electrical and Mechanical Engineers was held in New York to discuss the conservation of national resources.

April 1—Explosion in the Echo mine of Buery Brothers Coal and Coke Company, Fayette county, W. Va., killed four men.—Utah Fuel Company fined by the United States Government for conspiracy to defraud the Government of coal lands.

April 2—Coal strike inaugurated at Alberta, Canada.

April 9—Dynamite explosion in Berwind-White Coal Company's mine at Windber, Penn.; seven men killed, four entombed.

April 13—Twenty men were killed by a gas explosion at the Superior coal mine at Linton, Ind.

April 14—Sale of Alaska Copper and Coal Company's Bonanza mine to J. P. Morgan and the Guggenheims.—Eight hundred union coal miners of the Bend Coal Corporation, Johnstown, Penn., go on strike.

April 15—Gas explosion at George's Creek Coal and Iron Company's mine, Farmington, Va., killed three men.—Over 600 officers of the United States Steel Corporation met at Scottdale, Penn., to receive reports from the commission which visited coal industrial plants in Europe.

April 18—The directors of the United States Smelting, Refining and Mining Company purchased 100,000 shares of the company's stock from R. D. Evans.—Consolidated Silver Cobalt Mines, Ltd., assumed control of the Greene-Meehan Mining Company, Cobalt.

April 19—La Rose Consolidated Mining Company acquired control of the Lawson mine, Cobalt.

April 20—Judge Goff, of the U. S. Circuit Court of Appeals, issued order restraining Chesapeake & Ohio Railroad from increasing freight rates on coal from West Virginia points.

April 22—Isabella-Connellsville Company voted appropriation of $2,000,000 to begin construction work of plant on the Monongahela river.

April 30—The three-year wage agreement between the anthracite miners and operators signed.—Sale of the Walsh & Seibert coal lands in Indiana for $1,500,000 to the Equitable Trust and Savings Company, Chicago.—Strike at St. Joseph Lead Company's mines, Bonne Terre, Mo.; mills closed.

May 3—Supreme Court of the United States declared the commodity clause of the Hepburn Railroad Rate Act to be constitutional.

May 5—Pittsburg Coal Company, Westland, Penn., resumed operations after being closed eight months.

May 6—Construction of 560 by-product coke ovens at Gary, Ind., begun by the United States Steel Corporation.

May 7—The Stockton Colliery, Penn., employing 800 men, suspended operations until the fall.

May 11—The directors of the Shannon Copper Company voted to finance the Shannon & Arizona Railroad.

May 12—The Consolidation, Fairmont, Somerset, Clarksburg, and the Pittsburg & Fairmont Coal companies, and their subsidiaries, controlling 200,000 acres of land, formed a merger.

May 19—Death of Henry H. Rogers, president Amalgamated Copper Company.—Frick Coke Company started 1000 additional ovens.

May 21—The $60,000,000 merger of coke plants was completed.

May 22—Largest week's zinc-lead shipment from Joplin district for more than one year.—Price of zinc ore reached $43.50.

May 25—Six thousand miners went on strike in the Kanawha field.

May 28—A formal agreement made whereby the Standard Oil Company will control the Galician oil fields.—Hayden, Stone & Co. purchased control of Santa Rita Copper Company.

June 1—Frick Coke Company fired 1200 additional ovens in the Connellsville region.

June 5—Dominion Copper Company's property sold under foreclosure at Vancouver, B. C.

June 8—The Yukon Gold Company completed a 70-mile ditch from Twelve Mile river.

June 10—John D. Ryan elected president of Amalgamated Copper Company.—Benjamin B. Thayer elected president of Anaconda Copper Mining Company.

June 15—The Ontario Government sold 15 tracts of land on the Gillies Limit, Cobalt.—Plant of the Nevada Sulphur Company, Humboldt, Nev., burned. Loss, $100,000.

June 16—Jones & Laughlin Steel Company closed deal for coal land involving an expenditure of $4,000,000.

June 17—Jameson Coal and Coke Company closed deal for 7000 acres of coal land near Fairmont, W. Va. Consideration, $2,000,000.

June 18—A shipment of gold valued at $3,200,000 arrived at Seattle from Alaska.

June 23—Explosion in mine No. 4, Lackawanna Coal and Coke Company, Wehrum, Penn.; 17 killed.

July 2—The town of Cobalt, Ont., swept by fire, destroying the surface buildings of some of the mines.

July 6—Strike of employees belonging to the United Mine Workers of America, in the Cape Breton mines of the Dominion Coal Company. —Explosion at the Cedar Coal and Coke Company's mine at Tollerville, near Trinidad, Colo., killed nine men.

July 7—The Delaware, Lackawanna & Western Coal Company organized to handle the sales and transportation of coal mined by the Delaware, Lackawanna & Western Railroad Company, this action being taken to comply with the Hepburn law prohibiting railroads from carrying coal which they own.

July 8—Militia called to Glace Bay, Nova Scotia, to preserve order at the Dominion Coal Company's collieries.

July 10—Announcement of acquisition by the Cananea Consolidated Copper Company of the old W. C. Greene concessions for constructing four lines of railroad in northern Mexico, mainly in Sonora.

July 11—Serious explosion in the Belmez coal mine in Spain.

July 12—Formal organization of the Instituto Mexicano de Minas y Metalurgia.

July 14—Approval of the Secretary of the Interior of the right of way for an 8-in. pipe line to be laid by the Prairie Oil and Gas Company from the Glennpool field in Oklahoma, southeasterly to the Oklahoma-Arkansas State line, and to be eventually extended to Baton Rouge, La.

July 16—Fire started by lightning destroyed two tanks containing 100,000 bbl. of oil, belonging to the Prairie Oil and Gas Company, at Bartlesville, Okla.; also, one tank, each, belonging to the Creston and the Matson oil companies.

July 22—New agreement, running until Sept. 1, 1910, signed by the coal miners and operators in Wyoming.

July 23—Announcement of purchase by Calumet & Arizona interests of the San Felipe group, comprising 260 pertenencias in the Arizpe district, Sonora, Mexico.

July 26—Publication of THE MINERAL INDUSTRY, Vol. XVII.

Aug. 2—The United States Smelting, Refining and Mining Company obtained modified injunction permitting it to smelt copper and other ores in the Salt Lake valley, under certain restrictions, including the baghousing of the fumes and neutralizing of acid gases.

Aug. 3—Announcement of the purchase of the Tula iron properties in the state of Jalisco by the Mexican Iron and Steel Company.

Aug. 5—At Cordova, Alaska, a $50,000,000 mortgage was filed by the Copper River & Northwestern Railroad, a Guggenheim corporation, in favor of the Standard Trust Company, of New York, this being the largest mortgage ever filed in Alaska.

Aug. 6—New United States tariff law became effective.

Aug. 7—Preliminary proceedings for foreclosure of mortgage on Newhouse Mines and Smelters Corporation property in Beaver county, Utah, in accordance with the plan of reorganization.

Aug. 10—Strike of United Mine Workers results in the closing of the Spring Hill coal mines in Nova Scotia.

Aug. 12—The timber and mineral lands of the Sierra Madre Land and Lumber Company, formerly owned by Col. W. C. Greene, were transferred to the F. S. Pearson Syndicate, the consideration being $2,000,000.

Aug. 21—During this week, zinc ore in the Joplin district touched $51.50 base, the highest price since 1907.

Aug. 23—The merger of the principal Canadian producers of portland cement completed by the organization of the Canadian Consolidated Cement Company.

Aug. 25—Lake Superior Mining Institute convened at Ishpeming, Mich., for the fourteenth annual meeting, a three-day session on the Marquette range.

Aug. 29—Serious floods in the vicinity of Monterey, Mex., interfered with transport of ore.

Sept. 5—Union copper mine, Copperopolis, Cal., sold to Calaveras Copper Company by Ames estate, Boston.

Sept. 6—Hercules mill, Burke, Idaho, burned.

Sept. 8—Iron Mountain mine, Indian Springs, Cal., sold to United States Smelting, Refining and Mining Company.

Sept. 9—Announcement of closing of option on Butte-Ely property, Ely, Nevada, to Cole-Ryan interests.

Sept. 17—Old Dominion Copper Mining and Smelting Company awarded $2,029,000 in suit against A. S. Bigelow.

Sept. 24—Florence, Colo., smeltery sold at sheriff's sale.

Sept. 25—Announcement of purchase of Santa Gertrudis mine, Pachuca, by Camp Bird, Ltd., of London.

Sept. 27—Strike at Butte arising from internal dissension in the union was settled and mines all resumed work.

Sept. 27—American Mining Congress convened at Goldfield, Nevada.

Sept. 28—Boston & Colorado Smelting Company announced liquidation and the dismantling of the Argo smeltery at Denver.

Sept. 29—Tintic smeltery, Utah, closed.

Oct. 1—Copper converting plant started at the Torreon smeltery in Coahuila.

Oct. 3—Fifteen men killed in explosion in Northwestern Improvement Company's coal mine at Roslyn, Washington.

Oct. 5—Explosion in Extension coal mine at Nanaimo, B. C., resulted in loss of 30 men.

Oct. 6—Doyle-Burns suit involving an interest in the Portland mine, Cripple Creek, Colo., settled out of court.

Oct. 8—Announcement of the purchase of the Burro Mountain mine in New Mexico by Phelps, Dodge & Co., Inc.

Oct. 15—Smeltery of the Arizona United Mines Company at Johnson, Ariz., blown in.

Oct. 19—Receiver appointed for the Frances-Mohawk Mining and Leasing Company, of Goldfield, Nevada.

Oct. 21—Explosion in the Rock Island coal mine at Hartshorne, Okla., several men being killed.

Oct. 30—Twelve men killed in explosion in Cambria Steel Company's coal mine near Johnstown, Pennsylvania.

Nov. 1—Last spike is driven in Western Pacific railway.—Plant of North Ontario Reduction and Refining Company at Sturgeon Falls, Ont., burned

Nov. 2—The Saddle Mountain properties and a large interest in the London-Arizona Company in Arizona sold to the Development Company of America.

Nov. 6—W. A. Clark wins in prolonged suit brought by George A. Treadwell, alleging mismanagement of United Verde Copper Company.

Nov. 10—A fire at the Great Boulder mines of over $1,000,000.—Nine men killed in mine fire at Auchincloss coal mine, Wilkes-Barre, Penn.

Nov. 13—Fire in the St. Paul mine at Cherry, Ill., resulting in loss of life of more than 300. After a week 20 men were taken alive from the mine.

Nov. 20—Decision declaring the Standard Oil Company, of New Jersey, a violation of the Sherman law.—The new mining law for Mexico approved by the Senate without material change from that passed by the lower house. The law became effective Jan. 1, 1910.

Dec. 1—Needles smeltery and mining property of Arizona-Mexican Company sold to U. S. Smelting, Refining and Mining Company.—Over three million acres of oil lands in California, Utah and Wyoming withdrawn from entry by order of the President.—Strike of railroad switchmen in the Northwest interferes with mining at Butte and in Minnesota.—Majority of Cumberland-Ely stockholders exchange shares of that company, on basis of 3¼ for 1, for stock of the Nevada Consolidated Copper Company, thus practically effecting a merger.—Homestake mine, South Dakota, closed for indefinite period on account of threatened labor strike. Dividends suspended.

Dec. 4—Suit commenced against Utah Coppper Company by E. A. Wall for $3,870,000 for alleged trespass.—Fire at London mines of Tennessee Copper Company destroyed shaft house, imprisoned men being safely rescued.

Dec. 10—Utah Ore Sampling Company, capital $200,000 organized at Salt Lake, as a merger of Utah sampling works.

Dec. 11—First unit of 750 tons' capacity of the Ohio Copper Company's mill started at Lark, Utah.—British Columbia Copper Company placed orders for fourth blast furnace.

Dec. 12—Gold Belt mill in Clifton district, Arizona, started, this being the first gold mill in the district.

Dec. 13—Continental Copper Company at Keystone, S. D., closes mine on account of pending difficulties with the labor unions.

Dec. 15—The Pittsburg-Buffalo Coal Company bought a large tract of coal land in the Fairmont district, West Virginia.—Option on Reforma mine in Guerrero, Mexico, taken by Exploration Company, Ltd., of London for $10,000,000.

Dec. 16—Numerous arrests in connection with an alleged high-grading combine at Cobalt.—Government royalties on several of the Cobalt mines reduced.

Dec. 17—Merger of Dominion Coal Company and Dominion Iron and Steel Company of Nova Scotia effected at meeting at Montreal.

Dec. 18—Contracts let for 110 Koppers by-product coke ovens for the Lake Superior Corporation at Sault Ste. Marie, Ontario.

Dec. 21—Republic Mines Company of Spokane purchased from the Pearl Consolidated Mining Company the Lone Star-Surprise mines at Republic for $225,000.

Dec. 23—Eight men were killed in a gas explosion at mine "A" of the Chicago & Cartersville Coal Company, Herrin, Ilinois.

Dec. 31—Southern Pacific Railroad opened as far as Rosamorada, Tepic, Mexico.

ALUMINUM.

There were no developments in the aluminum business during 1909 which distinguished it particularly from the other metal industries of the country. It recovered from the effect of the business depression of 1907 to such an extent that at the close of the year it enjoyed a degree of prosperity which, while not equaling that immediately prior to the late panic, was probably all that could have been expected. The Aluminum Company of America continued in its monopoly of the production of aluminum in this country, but for the first time in the history of the industry the domestic market was seriously invaded by European producers. The heavily over-stocked foreign manufacturers offered aluminum in this country at a price lower than that of the American metal and that they did a fair volume of business is indicated by the fact that imports of aluminum amounted to over 5,000,000 lb. The year opened with the Aluminum Company of America quoting 23c. per lb. base for No. 1 ingots and 32@33c. base for sheets, while the foreign producers offered ingots at 22c. Prices remained at this level until July, when there was a slight recession, the American company asking 22c. per lb. for ingots and foreign producers offering them at 21c. per lb.

As regards the development of the industry in this country, most of the additions made by the Aluminum Company of America during 1909 con-

PRODUCTION, IMPORTS AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year.	Production.			Imports.			Exports.	Consumption
				Crude.		Mfrs.		
	Pounds.	Value.	Per lb.	Pounds.	Value.	Value.	Value	Value
1897..........	4,000,000	$1,400,000	$0.35	1,822	$1,082	$3,647	(a)	$1,404,729
1898..........	5,200,000	1,690,000	0.33	60	30	13,840	$238,997	1,474,268
1899..........	6,500,000	2,112,500	0.33	53,622	9,425	7,828	291,515	1,838,238
1900..........	7,150,000	2,288,000	0.32	256,559	44,455	5,989	281,821	2,056,623
1901..........	7,150,000	2,238,000	0.31	564,803	104,168	5,580	183,579	2,164,169
1902..........	7,300,000	2,284,590	0.31	745,217	215,032	3,819	116,052	2,387,389
1903..........	7,500,000	2,325,000	0.31	498,655	139,298	4,273	157,187	2,311,384
1904..........	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	2,494,952
1905..........	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	3,015,364
1906..........	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	4,957,907
1907..........	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	(b)
1908..........	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	(b)
1909..........	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	(b)

(a) Not reported. (b) Impossible to compute accurately in the absence of information as to unsold stocks.

sisted in completing work which was begun several years ago. The steam plant at its alumina works at East St. Louis was finished, thus increasing the company's alumina output. The new rolling mill at Niagara Falls was operated successfully and is now running approximately at full capacity. There were no increases in reduction plants during the year. At the New Kensington works the tube mill was doubled in size in order to meet the increased demand for tubing and the manufacturing plant was slightly enlarged.

PRICE OF ALUMINUM AT NEW YORK.
(In cents per pound.)

Grade.	Dec., 1905.	July 1906.	Dec., 1906.	July, 1907.	Dec., 1907.	July, 1908.	Dec., 1908.	July, 1909.	Dec., 1909.
99% pure	35	36	38	42	33	28	24	22	22
90% pure	33	34	37	41	32	27	23	21	21
No. 12 casting alloy	35	36	37	41	32	27	22	20	20
No. 21 casting alloy	33	34	35¼	39¼	30¼	24½	22½	20½	20½
No. 31 casting alloy	30	31	33¼	37¼	28¼	22½	21½	19½	19½

The above prices were for ton lots or over; the prices for small lots were 2 to 3c. per lb. higher.

WORLD'S PRODUCTION OF ALUMINUM.
(In metric tons.)

Year.	Great Britain.	France.	Switzerland, Germany. Austria.	North America.	Totals.
1897	(a)310	470	800	1,815	3,195
1898	310	565	810	2,359	4,034
1899	559	763	1,300	2,949	5,571
1900	569	1,026	2,500	3,244	7,339
1901	560	1,200	2,500	3,244	7,504
1902	600	1,355	2,500	3,312	7,767
1903	(b)650	1,570	(b)2,500	3,403	8,123
1904	(b)650	1,650	(b)3,000	3,494	8,794
1905	2,250	4,425	3,675	6,560	16,810
1906	2,500	4,500	4,000	7,325	18,325
1907	3,700	4,700	8,000	16,329	32,529
1908	(b)2,000	(b)6,000	(b)3,500	8,150	(c)20,250
1909	(b)2,800	(b)6,000	(b)5,000	(b)9,000	(d)24,200

(a) C. Le Neve Foster, British Mineral Statistics for 1897. (b) Statistics of Metallgesellschaft, Frankfurt am Main. (c) Includes 600 tons produced in Italy. (d) Includes 800 tons produced in Italy and 600 tons produced in Norway.

Market Conditions.—During 1909 the demand for aluminum increased rapidly, both in this country and abroad. This was due not only to improvement in general business conditions, but also to the popularizing of the use of the metal by its low price, and especially to an increase in its consumption, brought about by the rapid development of the automobile industry. In the face of this increased demand, production in Europe was noticeably curtailed, and prices even receded a little. This anomaly is to be explained by the unsatisfactory condition of the aluminum industry abroad. Throughout the period of general industrial depression which existed during 1907 and 1908 the production of aluminum was far in advance of its consumption, and large stocks of the metal were accumulated both in this country and in Europe. In consequence of the high prices maintained under the régime of the international syndicate many new producers entered the European field. The result is that the total foreign producing capacity of today is estimated at several times the total foreign consumption of a good business year like 1906. A crisis of over-production has resulted, and at the present time a struggle for actual existence is going on among the European producers. In consequence, prices have not responded to the increase in demand, and the best grade of ingot metal sold in Europe throughout 1909 at $12\frac{1}{2}$@14c. per lb. At these figures foreign producers have been able to invade the markets of the United States, and notwithstanding the import duty of 8c. per lb. (subsequently reduced to 7c.), have been able to underbid the Aluminum Company of America.

Under the Payne tariff, which went into effect on Aug. 5, 1909, the duty on ingot aluminum was reduced 1c. to 7c. per lb., and on sheets, rods, bars, etc., 2c. to 11c. per lb.

In an attempt to relieve the situation abroad, preliminary steps were taken to revive the international aluminum syndicate, which dissolved in September, 1908, by calling a meeting of the representatives of the French producers in Paris on July 19. Although at the time an agreement of coöperation seemed an assured thing, it is now stated that all hopes of an understanding have been abandoned. It is worthy of note that throughout the year aluminum sold in Europe at a lower price than copper, pound for pound.

Cost of Production.—According to excellent authority the cost of production of aluminum in this country is approximately 15c. per lb. (exclusive of amortization charges.)

At present prices, therefore, the Aluminum Company of America is making a good profit, and considering that there has been no large reduction in its manufacturing cost during the last three or four years, during which period the price of aluminum has averaged 35c. per lb., one can readily understand what enormous profits this company has been making and how it has been possible for it to recently declare a 500-per cent. stock dividend. As to the cost of aluminum production abroad, there is a considerable difference, according to the location of the various plants with reference to the supply of bauxite, cheap power, proximity to market, etc. A recent writer in *L'Echo des Mines* says: "For those large companies possessing cheap marketing facilities, bauxite mines, and plants for the manufacture of alumina, the net cost of production of aluminum oscillates around 120 fr. per 100 kg." This figure is equivalent to 10½c. per lb. and can be accepted as the cost of production under the most favorable circumstances. For plants less fortunately situated, the cost of manufacture is in some cases probably as high as 13c. per lb.

M. Lodin estimates the average cost of production in the French plants at 1.305 fr. per kg. or 11.4c. per lb. This figure does not include general or office expense, and is made up of the following items: Alumina, 0.585 fr.; cryolite, 0.075 fr.; electrodes, 0.28 fr.; labor, 0.125 fr, and electric power, 0.24 fr. The *Frankfurter Zeitung* is authority for the statement that the present average price of 14c. per lb. for crude aluminum represents only a small profit, but it no longer directly results in a loss. The cost of European production of aluminum may, therefore, be taken at from 10½ to 13c. per lb. Large quantities of aluminum have been sold in Europe during the year at 12c. per lb., and as this figure is below the estimated cost of production of some of the plants, it readily explains why a number of the foreign producers are turning to the manufacture of other products. Even the Neuhausen Aluminum Industry Company, a pioneer in the European aluminum business, has commenced the manufacture of nitric acid and nitrates from atmospheric nitrogen at one of its works.

Prospects of Competition.—Although there was considerable foreign metal sold in the United States in 1909, the Aluminum Company of America can at any moment take absolute control of the domestic market by dropping its present price a cent or two. By doing this it would still be able to make a profit and would oblige imported stock to be sold at a loss. As long as the present tariff exists, foreign competition is therefore largely eliminated, but freedom from domestic competition is no longer assured the Aluminum Company of America. The Bradley patents, which were the last of the principal basic patents, protecting the process of manufacture of aluminum as carried on by the above mentioned company, expired in February, 1909. Even with the large advantages of a long-established and well-organized business, ample facilities in the way of hydro-electric power and supplies of raw material, plenty of capital, and the fact that it is at present able to manufacture more than sufficient metal to take care of domestic consumption; this company cannot hope to deter other metallurgical interests from engaging in the production of aluminum if it continues in the "standpat" policy of high prices, which it has followed to date. Developments, however, seem to indicate that this company is about to make a radical change in its previous policy, and that at present it is planning to retain its grip on the industry by greatly increasing its output and popularizing the use of the metal by a further reduction in price, relying upon the derivation of a substantial profit from a large volume of sales. It is prepared, to carry out this new policy by an extensive enlargement of its present capacity. With this in view it has applied to the Canadian Government for the privilege of damming the St. Lawrence river, near Brockville, N. Y., so as to obtain a water power of about 800,000 h.p., which will be used in additional plants at Massena, N. Y. On account of the adoption of this policy of extension and low prices it is reasonable to suppose that pending an abnormal increase in the consumption of aluminum, the Aluminum Company of America will meet with no immediate domestic competition.

The Metallurgy and Uses of Aluminium in 1909.[1]

By Joseph W. Richards.

In 1909 the Aluminium Company of America installed a plant at Dover, N. J., for the manufacture of aluminium bronzing powder, a material hitherto imported from Europe. The white metallic powder made at Dover is of the highest grade, and while the domestic production of this material is too new to warrant any prophecy as to its increased use, it is not unlikely that the establishment of this domestic source of supply will result in somewhat lower prices and a consequent larger consumption of aluminium powder for painting, lettering and the other uses to which it is adapted. E. K. Abrest finds aluminium powder to contain small amounts of iron, silica, carbon and nitrogen, but not more than is present in good commercial metal. There is present, however, 2.3 per cent. of oxygen, probably as alumina, which makes the real composition of the powder 92.5 per cent. metallic aluminium, 5.72 per cent. alumina, and 1.78 per cent. impurities.

Regarding the bath used in producing aluminium, M. Moldenhauer gives the melting point of cryolite as 975 deg. C, and of cryolite with 20 per cent. of dissolved alumina, as 880 deg. C.

There is one condition affecting the consumption of aluminium which is particularly gratifying, namely, that aluminium seems finally to have attained a position among commercial metals where it is treated entirely on its merits. In the early days of the industry the claims for aluminium with regard to its non-corrosive qualities, lightness, and other distinguishing characteristics, were so exaggerated that it failed to measure up to the expectations thus created. It was tried in many uses to which it was not suited and a reaction occurred, so that the real merits which the metal posesses have been somewhat discounted for a number of years.

[1] The spelling "aluminium" has been retained in this article in deference to the well-known wish of Professor Richards Elsewhere in this volume the conventional American form of "aluminum" is employed.—*Editor.*

This condition no longer exists and today aluminium is ranked among metals according to its real value. An evidence of this is seen in its rapidly increasing use for vats, tanks and similar vessels employed in the manufacture of medicines, wines, the preserving of fruit, the recovery of glycerine, and similar industries, a field to which its characteristics especially adapt it.

The soldering or welding of aluminium has always presented great difficulties, since no flux has yet been discovered which permits of its being as readily soldered as other metals. The recent development, however, of the oxy-acetylene burner has done much to facilitate the welding of aluminium, which has been practised to a greater extent during the year just past than at any previous time. By this means aluminium vessels of practically any size and thickness of metal may be welded—if not as readily as copper at least in a manner which is entirely practicable and which gives a more durable joint than the soldered joints of other metals. The success of welded joints has encouraged the manufacture of aluminium vats, tanks and similar apparatus in the industries above mentioned. The repairing of aluminium castings by oxy-acetylene welding insures a wider use and greater popularity of aluminium for castings.

During 1909 aluminium has been applied to no new uses of importance, although several of the more recent applications of the metal have been considerably developed. Aluminium tubing is becoming more widely used, due to its increase in favor for those purposes to which it has been applied for years. The uses for ingot and sheet aluminium do not seem to increase in number, although, as in the case of aluminium tubing, the quantity consumed is increasing rapidly. Among the growing uses of aluminium tubing is its employment in the form of bimetallic (aluminium-copper) tubes in surface steam condensers. Bimetallic aluminium tubing, composed of a copper envelope over an aluminium lining, or *vice versa,* is unlikely to split, owing to its laminated structure, and possesses greater durability than any other condenser tubes hitherto used. The greater durability of an aluminium-copper tube is due, first, to the resistance of aluminium to the corrosive influences of impurities in cooling water, and, second, to the galvanic action induced between the two metals after the aluminium lining is finally perforated. Aluminium, being electropositive to copper, protects it from corrosion in somewhat the same way than even porous galvanizing protects iron. The large number of cases in which it has been successfully employed in substitution for tubes made of Muntz metal, bronze or copper assure a considerable consumption of aluminium tubing for this class of work.

Another increasing use of aluminium is its application in the form of sheets as a substitute for rubber matting, linoleums and similar substances for treads in the floors and steps of automobiles, carriages and other places where a firm footing is essential. By passing sheet aluminium through suitably cut rolls the metal is given a pyramided surface and is known as "pyramidic sheet." When this sheet is given the proper finish it has the uniform white surface of new rubber matting without the disadvantages of rubber matting and its substitutes.

Extruded aluminium shapes are becoming more widely used in such forms as moldings and angles adapted for carriage and automobile bodies.

The interesting magnetizable aluminium alloys have been further investigated by Heusler and Richarz. They find that forged alloys containing 6 per cent. or more of aluminium, 20 per cent. or less of manganese, and the rest copper, are entirely non-magnetic when quenched from a red heat in water or mercury, but on heating several hours in boiling xylene acquire a maximum of magnetizability, without showing hysteresis. However, if these alloys are cooled slowly through the critical range of temperature they show hysteresis.

Bibliography of Aluminum in 1909.

Anonymous. "Aluminum as an Electrical Conductor." (*Min. Journ.*, Feb. 20, 1909; ½ p.)

Anonymous. "Making Aluminum Foil of Extreme Thinness." (*Brass Wld.*, May, 1909; 2 pp.)

Anonymous. "Some Notes on Making Aluminum Castings in Green Sand Molds." (*Brass Wld.*, Aug., 1909; 3¼ pp.)

Anonymous. "Three New British Aluminum Works." (*Electrochem and Met. Ind.*, Jan., 1909; 3¾ pp.)

Bock, F. "Die Elektrische Reduktion des Aluminums ein Laboratoriums Experiment." (*Elek. Zeit.*, Aug., 1909; 4 pp.)

Echevarri, J. P. W. "Aluminum and Some of Its Uses." (*Eng. Digest*, Jan., 1909; 1½ pp.)

Lodin, M. "Note sur la Fabrication Electrotytique de l'Aluminium." (*Ann. des Mines*, XVI, 1909; 65 pp.)

Moldenhauer, Max. "Ueber Verwendbarkeit von Tonerdesilikaten zur Aluminiumfabrikation." (*Metallurgie*, Jan. 8, 1909; 7⅓ pp.)

Pecheux, H. "Influence of Impurities on the Thermo-electric Properties and Electrical Resistance of Aluminum." (*Compt. rend.*, 1909; 1 p.)

Pitaval, R. "L'Industrie de l'Aluminium en France." (*Bull.* Soc. Ing. Civ. de France, Nov., 1909; 25 pp.)

Sayles, J. A. "Directions for Hardening Aluminum with Copper." (*Brass Wld.*, Jan., 1909; ¾ p.)

SCHOOP, M. U. "Autogenous Welding of Aluminum." (*Electrochem. and Met. Ind.*, April, 1909; 2 pp.)

SCHOOP, M. U. "Aluminum Welding." (*Electrochem. and Met. Ind.*, May, 1909; 2 pp.)

THOMPSON, M. DE KAY. "Electrolytic Reduction of Aluminum as a Laboratory Experiment." (*Electrochem. and Met. Ind.*, Jan., 1909; 2 pp.)

TUCKER, S. A. "Preparation of Aluminum in the Laboratory." (*Electrochem. and Met. Ind.*, July, 1909; 3/4 p.)

WILSON, E. B. "Aluminum." (*Mines and Minerals*, Mar., 1909; 1 1/8 pp.)

WILSON, V. H. "Aluminum; Its Future as a Substitute for Copper Wire." (*Yale Sci. Monthly*, Nov., 1909; 2 1/2 pp.)

ALUNDUM.

The production of alundum in the United States in 1909 was over 100 per cent. greater than in any previous year. The Norton Company of Worcester, Mass., with works at Niagara Falls, N. Y., continues to be the sole producer of this abrasive. Prices were the same as during 1908, loose grain bringing 6c. per lb. The quantity and value of alundum produced since its manufacture was begun in 1904 are shown in the accompanying table:

PRODUCTION OF ALUNDUM IN THE UNITED STATES.

Year	Pounds.	Value.
1904	4,020.000	$281,400
1905	3,612,000	252,840
1906	4,331,233	303,186
1907	6,751,444	405,086
1908	3,160,000	189,600
1909	13,578,000	814,680

Alundum is prepared by melting calcined bauxite in specially designed electric furnaces. For calcining the bauxite the Norton Company uses a 60-ft. rotary calciner heated by producer gas and capable of treating 40 tons per day. After calcining, the ore is melted in conical shaped water-jacketed furnaces with vertical electrodes and having a capacity of about three tons each. During the fusion iron containing 5 to 12 per cent. silicon is reduced. After cooling the fused mass is broken up and the ferro-silicon sorted out to be sold to steel makers. The alundum, after crushing and sizing, is ready to manufacture into grinding wheels, sharpening tools, etc.

Alundum corresponds to corundum in chemical composition, but is harder than that mineral. It melts at 2300 deg. C., has an extremely low coefficient of expansion and is very inert chemically. One of its most recent applications is as a refractory material, and tests made in the basic open-hearth furnace show that it is not appreciably affected by slags in that process. Although its cost is comparatively high, it will undoubtedly prove of great value as a refractory for many special purposes.

AMMONIA AND AMMONIUM SULPHATE.

By C. G. Atwater.

The production, or, perhaps more accurately, the recovery of ammonia in the United States increased regularly each year from 1898 to 1908. The boom in business, particularly in the iron and steel lines, in the year 1907 resulted in a production of 99,300 tons of sulphate of ammonia, all forms of ammonia produced being reckoned as sulphate. According to the figures of the U. S. Geological Survey and with due allowance for ammonia recovered from other sources than bituminous coal, the depression of the following year reduced the output to 83,400 tons. This was a loss of nearly 16,000 tons and was due principally to the smaller number of by-product coke ovens in operation and the consequent drop in the quantity of ammonia recovered, though the production from coal-gas works fell off to some extent as well. As the drop in recovery from coal-gas retorts may be reasonably ascribed to the increasing favor manifested for carburetted water gas and oil gas rather than to dull business conditions there is little reason to expect much increase from that source during 1909, or for the year to come. This is not the case, however, with the by-product coke ovens. Their number was augmented in the latter part of 1908 by the operation of one of the four batteries comprising the 280-oven installation at Joliet, Ill., and the remainder of the plant started up in 1909. Besides this 50 ovens were added to the Hamilton, Ohio, plant, 15 to the Geneva, N. Y., plant and 50 new ovens were built and started at Indianapolis, Ind. The ammonia production was increased also by the resumption of operations during 1909 at a number of plants that had been wholly or partly idle for a time.

From reports made to me by all, or nearly all, of the by-product coke-oven plants in the country, their ammonia output for the year 1909, reckoned as sulphate, may be placed at 75,000 tons, a high-water mark for the industry. Estimating the output from gas works and that from other sources at a little below the figures for the preceding year, we may reckon the total recovery for 1909, expressed in terms of the sulphate equivalent, at very close to 106,500 tons. This is 23,100 tons in excess of the 1908 output and 7200 tons more than the recovery in 1907, the best previous year. The return to a respectable annual increase in production augurs well for the immediate future of the industry, and there are other and even more favorable indications. The United States Steel Corporation has the construction of a 500-oven plant at Gary, Indiana, well under way, and will probably build additional ovens at Ensley, Alabama, and elsewhere in the near future. The Bethlehem Steel Company is reported to have contracted for a large plant of by-product ovens, and others of the independent steel works are considering additions to existing plants or the installation of new ones. The United States production of sulphate of ammonia and sulphate equivalent for each year since 1897 is given in Table I.

TABLE I.—UNITED STATES AMMONIA PRODUCTION, EXPRESSED IN SULPHATE EQUIVALENT. (a)
(Tons of 2000 ℔.)

Year.	Tons.	Year.	Tons.	Year.	Tons.
1898	17,000	(b) 1902	36,124	1906	(b) 75,000
1899	19,500	1903	41,873	1907	99,309
1900	(b) 27,600	1904	54,664	1908	83,400
1901	(b) 29,279	1905	65,296	1909	(b) 106,500

(a) Statistics of the U. S. Geological Survey except where noted as estimates. Allowance has been made for the ammonia produced in the bone-black industry.
(b) Estimated.

The United States imports for the fiscal year ended June 30, 1909, amounted to 40,192 tons, as compared with 34,274 tons in 1908 and 32,669 tons in 1907, showing that imports increased regularly in spite of the general business depression of 1908, and that the revival of business in 1909 brought larger imports as well as larger production. Imports for the years since 1900 are given in Table II, together with the total consumption and the average market quotation for each year.

TABLE II.—UNITED STATES AMMONIA CONSUMPTION, EXPRESSED IN SULPHATE EQUIVALENT. (a)
(In tons of 2000 ℔.)

Year.	1901	1902	1903	1904	1905	1906	1907	1908	1909
Imports...............	14,486	18,146	16,777	16,667	15,288	9,182	32,669	34,274	40,192
Total consumption.....	43,765	54,270	58,650	71,331	80,584	84,182	132,000	121,874	149,192
Average price..........	$55.16	$59.90	$62.10	$61.71	$62.92	$62.33	$61.93	$59.90	$56.04

(a) The figures for consumption and price are for the calendar year, while those for imports are for the fiscal year ending June 30.

The fluctuation of prices during 1909 was considerable, due to the revision of the tariff. The price ranged between $2.89 and $3.01 per 100 ℔. for the first half of the year, the maximum quotation being reached during February. At the beginning of August the price was still $2.87, but on August 6 the new tariff bill, which removed the import duty of 30c. per 100 lb., went into effect, and this, aided by the fact that it was the quiet season for fertilizer materials, resulted in a drop of the price to $2.65. Quotations on about this level prevailed for the balance of the year, the imported article going as low as $2.60 in New York, but the purchases were not large at the lower rates, being largely confined to those who saw that a later rise in price was probable and who were financially able to buy and hold for the spring requirements. By the end of December the price of domestic was up to $2.67½ and at present writing (March, 1910) has risen to $2.85 per 100 lb. The average quotation for domestic for the first six months of 1909 was $2.90 and for the last six months a shade under $2.70, making the average price for the year almost exactly $2.80. According to these figures, and in view of the increasing production and consumption the price of sulphate of ammonia may be said to depend at present more on the ratio of supply to demand than on the influence of a protective tariff. As a matter of fact there is no large surplus of sulphate of ammonia available to bring into this country from any source. In spite of the fact that the world's production has now increased to about 980,000 tons per annum, there is a market for it all, and for any considerable increase in our imports a price must be paid that will divert it from other consumers.

United Kingdom.—The production of ammonium sulphate and sulphate equivalent in the United Kingdom for the past eight years is given in Table III.

TABLE III.—AMMONIUM SULPHATE AND SULPHATE EQUIVALENT PRODUCED IN THE UNITED KINGDOM. (*a*)

(Tons of 2240 lb.)

Year.	1902	1903	1904	1905	1906	1907	1908	1909
Gas works	150,055	149,489	150,208	155,957	157,160	165,474	165,218	164,276
Iron works	18,801	19,119	19,568	20,376	21,284	21,024	18,131	20,228
Shale works	36,931	37,353	42,486	46,344	48,534	51,338	53,628	57,048
Coke ovens	15,352	17,438	20,848	30,732	43,677	53,572	64,227	82,886
Producer gas and carbonizing works	8,177	10,265	12,880	15,705	18,736	21,873	24,024	24,705
Total	229,316	233,664	245,990	269,114	289,391	313,281	325,228	349,143

(*a*) These figures are from the Alkali Inspector's reports.

As will be noted, the production from coal-gas works, which remained practically stationary from 1907 to 1908 declined, registering a decrease of 942 tons. This decrease was overbalanced by a considerable increase in the shale industry and by a very much larger gain, aggregating 19,340 tons, in the output of the by-product coke ovens, producer-gas and carbonizing works. The latter increase was foreshadowed by the number of by-product coke ovens that have been built in England recently, and, as has been stated before, the prospects for further increase in production from this source are good. In order to arrive at an idea of what this development may amount to we may take a recently published figure, apparently from authoritative sources, that gives the amount of coal used in making coke in Great Britain in 1908, as 35,233,523 tons. Reckoning the yield in sulphate of ammonia as 1 per cent. of this amount we have about 352,000 tons, and adding together the output of the gas works, 165,218 tons, and that of the coke ovens, 64,227 tons, for the year 1908, we have but 229,445 tons. The latter figure is less by over 122,000 tons than the possible recovery, based on the coal actually made into coke; or, stated in terms of percentage, the actual recovery was but 60 per cent. of that possible. The increase of some 18,000 tons in the 1909 output of the gas works and coke ovens would raise the percentage to 70 per cent. provided that the coal consumption was not also increased, which would hardly be a fair assumption. It is clear, however, that the prospects of increased production from England have by no means reached their limit.

Lest Englishmen should consider the above figures as casting a reflection on the industries in question, it may be well, in passing, to indicate that the proportion of actual ammonia recovery to that which is possible is far less in this country than in England. The 1908 figures given out by the U. S. Geological Survey show that the total amount of coal used in coke-oven plants and in gas works was about 43,000,000 tons, which should have yielded 430,000 tons of sulphate of ammonia. The actual recovery was but 83,400 tons, or less than 20 per cent.; therefore, whatever has been said in regard to the situation in the United Kingdom applies with three-fold emphasis to this country as well.

In Germany, however, the conditions are strikingly different. The coke production of that country is given as 21,400,000 metric tons for the year 1909. Assuming the low figure of 70 per cent. as the yield of coke under the conditions that prevail there, we have 30,600,000 tons as the coal used in making this coke. Taking the same yield of ammonium sulphate as before, viz., 1 per cent., we have 306,000 tons as the maximum recovery to be expected. The actual production of the country in 1909 was 340,000 tons, which includes the sulphate of ammonia derived from coal-gas works. The latter source yielded about 30,000 tons in 1907, and there is small reason to assume that it had increased in two years more than enough to make up the difference between the estimated coke-oven output and the total production. In other words, Germany very closely approximates a recovery of 100 per cent., figuring on the same basis as for England and the United States.

The amount of sulphate of ammonia and sulphate equivalent consumed in the United Kingdom in 1909 is estimated at 87,000 tons. The price at Hull averaged £11 5s. 0d. per ton for the year, a falling off of 7s. from the 1908 average, and equivalent to about $48.92 per short ton. The United Kingdom is still, as hitherto, the largest exporter of sulphate of ammonia. During 1909 her exports amounted to 264,041 tons, of which Spain and Portugal took 56,137 tons, Japan 49,275 tons, the United States 35,080 tons and Germany 30,545 tons. Java alone took 32,027 tons, while France, an excellent customer in 1908, took but 12,030 tons, and Italy, long numbered among the smaller consumers, received 10,590 tons. The remaining countries took amounts of under 10,000 tons.

TABLE IV.—PRODUCTION OF AMMONIUM SULPHATE AND SULPHATE EQUIVALENT FROM BY-PRODUCT COKE OVENS AND GAS WORKS IN GERMANY. (a)

(In metric tons of 2204.6 lb.)

Year.	1901	1902	1903	1904	1905	1906	1907	1908	1909
Gas works..	17,000	18,000	20,000	21,000	22,000	....	(b)30,000	....	....
Coke ovens.	113,000	117,000	120,000	152,000	168,000	....	257,000	....	....
Total...	130,000	135,000	140,000	173,000	190,000	(b)235,000	(b)287,000	(b)313,000	(c)340,000

(a) Dr. N. Caro, *Zeit. f. angew. Chem.*, Sept. 14, 1906. (b) Deutsche Ammoniak-Verkaufs-Vereinigung, 1906-7-8. (c) Bradbury and Hirsch's Review, 1909.

Germany.—The figures given in Table IV show that Germany still maintains her astonishing increase in production. The figure of 340,000 metric tons for the year 1909 shows a gain of some 27,000 tons over the quantity made in 1908, and is nearly double the output of 1904. Whether such a succession of increases can be kept up is questionable, in view of the thoroughness with which the field offered by her coke production has already been exploited. England and Germany are now about on a parity as producers, but, unless the latter country should develop a coal-gas industry commensurate with that of England it seems probable that the English production will increase the more rapidly from now on. There are no figures at hand as yet for the total imports, exports or home consumption in Germany, but as the home market absorbed about 284,000 tons in 1908, a similar amount or perhaps a little more, may be taken as the consumption in 1909. *L'Engrais* estimates the German consumption at 300,000 tons, so that it may be fairly assumed that the difference between the imports and exports, in other words the net exports, would amount to between 40,000 and 50,000 tons for the year 1909.

France.—The sources and amount of the French production for the past two years are given in Table V.

TABLE V.—AMMONIUM SULPHATE AND SULPHATE EQUIVALENT PRODUCED IN FRANCE

(Metric tons of 2204.6 lb.).

	1908.	1909.
Gas Works, Paris and vicinity	14,000	14,000
Provincial Gas Works	4,000	4,000
By-product coke ovens	21,700	22,800
Sewage disposal	11,500	11,300
Shale works	900	900
Various sources	500	600
Total	52,600	53,600

These figures show that France produced 53,600 metric tons in 1909, a gain of 1000 tons over the 1908 output, due principally to the increase in the amount from coke ovens. The consumption of France is given by *L'Engrais* at 89,000 tons for the year.

Japan.—The imports into Japan from England for the years since 1900 are given in Table VI. In addition to these amounts Germany sent 9889 tons to Japan in 1908. It will be noted that while Japan has not continued the rate of importation appearing in 1907, nevertheless her consumption has been large and on a generally increasing scale.

TABLE VI.—EXPORTS OF AMMONIUM SULPHATE FROM THE UNITED KINGDOM TO JAPAN.

(Tons of 2240 lb.)

1901	1902	1903	1904	1905	1906	1907	1908	1909
1,290	2,429	3,612	14,981	33,861	33,237	64,270	38,745	49,275

TABLE VII.—ESTIMATED WORLD'S PRODUCTION OF AMMONIUM SULPHATE AND SULPHATE EQUIVALENT.

(Metric tons of 2204.6 lb.)

Country	1902	1903	1904	1905	1906	1907	1908	1909
England	233,100	237,520	250,050	273,550	294,170	318,400	330,450	354,747
Germany	135,000	140,000	173,000	190,000	235,000	287,000	313,000	340,000
United States	32,800	38,000	49,600	59,250	68,000	90,120	79,500	96,600
France (*b*)	40,000	52,000	43,000	47,300	49,100	57,200	52,600	53,600
Belgium and Holland (*b*)	38,000	35,000	(*a*)39,000	24,200	30,000	(*a*)55,000	(*d*)35,000	40,000
Spain (*b*)				10,000	10,000	(*c*)12,000	12,000	12,000
Italy (*b*)	45,000	45,000	48,000	4,500	5,000	11,000	11,000	12,000
Other Countries (*b*)				40,500	40,000	65,000	67,500	73,000
Total	523,900	547,520	602,650	649,300	731,270	991,200	901,050	981,947

(*a*) Including Norway, Sweden and Denmark. (*b*) Estimates from *L'Engrais*. (*c*) Including Portugal. (*d*) Estimates from Deutsche Ammoniak-Verkaufs-Vereinigung, 1908.

Table VII gives an estimate of the world's production of sulphate of ammonia and sulphate equivalent for the last few years. As will be noted from these figures, the increase in production has been constant and large, the amount for 1909 approximating a million tons. Later and more reliable figures are more likely to increase the total than to diminish it, therefore, it is fairly certain that the million mark has been passed. In this connection it is of interest to note that the shipments of nitrate of soda, the other great nitrogen-supplying chemical, amounted to a little over 2,000,000 tons in 1909. If we allow for the greater amount of nitrogen in sulphate of ammonia, the ratio being about as 4:3, it will be found that of the total nitrogen supplied by the 3,000,000 tons of combined material nearly 40 per cent. is derived from the sulphate of ammonia.

ANTIMONY.

By F. T. Havard.

The production of antimony in the United States in 1909 continued to be small, Mathison & Co. being the only smelters making the metal. This firm treats little or no domestic ore and is really a subsidiary of one of the larger English companies which obtains the advantage of the higher prices for antimony ruling in the United States by supplying ore to the smeltery on Staten Island.

In the mining of antimony proper, there was little or no activity, the total production for 1909 amounting to 95 tons valued at $4700. A number of western mines still have on their property parcels of ore which were mined during or directly after the boom days of 1906 and 1907. Although but little antimony ore was mined or sold in the United States during 1909, yet a considerable quantity of this metal was contained in some of the lead ores smelted. The accompanying table gives the imports, exports, production, and consumption of antimony in the United States since 1896.

ANTIMONY STATISTICS OF THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Imports.		Exports.		Production.			Consumption
	Metal or Regulus.	Ore	Metal or Regulus.	Ore.	In Hard Lead.	From Domestic Ore.	From Imported Ore. (a)	
	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons	Short tons
1897	573	2,751	....	....	2,217	245	1,100	4,135
1898	1,013	1,863	13	17	2,118	250	738	4,106
1899	1,580	1,991	*Nil.*	*Nil.*	1,586	234	796	4,196
1900	1,816	3,018	21	*Nil.*	2,476	151	1,207	5,638
1901	1,837	866	*Nil.*	25	2,235	50	336	4,458
1902	2,871	840	37	104	2,904	*Nil.*	294	6,032
1903	2,563	1,337	40	*Nil.*	2,552	*Nil.*	535	5,610
1904	2,028	1,245	16	214	2,515	*Nil.*	412	4,939
1905	2,869	988	*Nil.*	*Nil.*	2,561	*Nil.*	395	5,825
1906	3,950	1,124	12	*Nil.*	2,358	150	450	6,866
1907	4,331	1,380	24	6	2,240	105	552	7,204
1908	4,057	1,640	1	5	2,621	180	656	7,513
1909	4,779	1,736	3	*Nil.*	2,546	38	694	8,055

(a) Estimated at 40 per cent. extraction from net imports of ore.

The only occurrence of any importance in the antimony industry during 1909 was the imposition by the United States Government of an additional import duty of ¾c. per lb., making a total duty of 1½c. per lb.

This was done to stimulate the production of American ores, but it is probable that an increased production will be effected by nothing less than a considerable rise in the market price. Until the industry shows a great increase in activity and the supply of available hard lead is unable to meet the demands of the trade, we need not expect very much change in the price. For I am convinced that a large proportion of the antimony which was sold during the boom days was used for purposes for which hard lead might be applied.

One other condition which might affect the price lies in the possibility of the more extensive use of antimonial pigments in Europe which would encourage the French smelteries, now making 60 per cent. of the world's output of refined antimony products, to increase their tonnage of oxides, with a proportional reduction in the amount of refined metal put on the market.

A similar condition may possibly obtain at some future time in America, for a little over a year ago the Harwood, Fuller & Goodwin Co., of Cleveland, commenced producing antimony oxide at its works in Elyria, Ohio. Until recently, this oxide, of which already a considerable quantity is used in the United States, was imported from Europe.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK.
(Cents per pound.)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901													
Cookson's	10.00	10.00	10.00	10.31	10.25	10.25	10.25	10.25	10.12	10.09	10.00	10.00	10.12
Hallett's	9.12	9.22	8.90	8.94	8.75	8.75	8.75	8.43	8.50	8.47	8.37	8.31	8.74
Others	9.25	8.85	8.77	8.73	8.63	8.63	8.63	8.50	8.37	8.34	8.25	8.00	8.55
1902.													
Cookson's	10.00	10.00	9.87	9.87	9.87	9.87	9.75	9.75	9.69	9.44	9.25	9.20	9.71
Hallett's	8.17	8.04	8.06	8.06	8.17	8.25	8.25	8.15	7.92	7.72	7.44	7.25	7.98
Others	7.86	7.75	7.75	7.75	7.90	8.00	8.00	7.90	7.65	7.37	7.22	6.92	7.67
1903.													
Cookson's	8.25	8.25	8.25	8.25	8.00	7.50	7.44	7.15	7.00	7.00	6.56	6.75	7.53
Hallett's	7.00	7.00	6.87	6.87	6.75	6.69	6.50	6.40	6.34	6.25	6.25	6.35	6.69
Others	6.75	6.62	6.50	6.50	6.50	6.44	6.25	6.19	6.00	6.00	6.00	5.95	6.31
1904.													
Cookson's	6.938	7.594	7.875	7.875	7.531	7.200	7.188	7.188	6.913	6.984	7.592	8.388	7.439
Hallett's	6.250	6.781	6.825	6.750	6.578	6.438	6.485	6.688	6.537	6.578	7.328	8.160	6.783
Others	5.688	6.203	6.475	6.406	6.203	5.961	5.969	6.062	6.015	6.172	7.204	8.088	6.371
1905													
Cookson's	8.375	8.375	8.375	8.219	8.406	11.025	12.625	14.500	13.700	13.000	12.500	14.000	11.100
Others	8.063	8.063	7.638	8.125	8.406	10.175	11.875	13.500	12.900	12.000	11.250	12.750	10.400
1906.													
Cookson's	15.0	16.0	17.5	21.31	25.25	26.0	25.25	25.0	24.5	25.2	26.14	26.25	22.78
Hallett's	14.0	15.0	16.5	20.81	24.38	25.0	24.25	24.0	24.0	24.81	25.25	25.24	21.94
Others	13.5	14.25	16.15	20.25	23.31	24.0	23.19	22.75	22.25	23.63	24.50	24.70	21.73
1907.													
Cookson's	25.906	25.062	24.90	24.125	21.937	15.75	11.875	10.906	10.75	11.75	11.00	9.662	16.969
Hallett's	25.219	24.062	23.75	21.344	18.562	13.812	10.50	9.687	10.00	10.406	9.937	9.05	15.527
Others	24.156	23.437	23.025	20.875	17.75	12.65	10.125	9.375	9.65	10.047	8.906	8.088	14.840
1908.													
Cookson's	9.344	9.266	9.000	8.969	8.875	8.734	8.594	8.313	8.234	8.284	8.640	8.200	8.704
Hallett's	9.031	9.016	8.650	8.672	8.625	8.531	8.375	8.150	7.922	7.922	8.075	8.063	8.419
Others	8.344	8.406	7.988	8.297	8.250	8.094	8.125	7.850	7.609	7.625	7.775	7.688	8.004
1909.													
Cookson's	8.202	8.125	8.047	8.250	8.387	8.312	8.375	8.525	8.687	8.537	8.437	8.437	8.360
U. S.	8.075	8.000	7.843	8.031	8.150	8.062	7.875	8.125	8.125	8.012	7.937	7.937	8.015
Others	7.675	7.531	7.500	7.718	7.887	7.893	7.375	7.625	7.506	7.500	7.687	7.687	7.466

The new enterprise seems to be established, for after a long series of experiments, the Cleveland company succeeding in producing a commercial grade of oxide from the sulphide, using natural gas as fuel, and, during 1909, exploited the use of the oxide in the paint, ceramic, glass, and enameling trades to a great extent.

Market.—The market for antimony during 1909 was very quiet. The low prices were due as of old to the heavy production in Australia and southern Europe and also to the large supply furnished by China. Throughout 1908 prices for Cookson's fluctuated between narrow limits; in January the average price was 8.202c. per ℔. and in December it was 8.360c. per ℔. Other brands closely followed the lead of Cookson's.

The position of domestic antimony oxide was strengthened by the recent tariff revision by which the 25 per cent. *ad valorem* duty on imported material was increased by a specific duty of 1½c. per ℔. The price quoted by the manufacturers of antimony oxide was 8c. per ℔. in a large way, but it is understood that concessions were made when any danger from foreign competition was feared. The domestic product controls practically 90 per cent. of the United States market for this material.

Production of Antimony in Foreign Countries.

Among producers of the actual metal, China easily leads, its exports of regulus and metal in 1908 amounting to 9356 metric tons, or more than twice the combined production of all other countries. The principal mines are situated in the province of Hunan, northwest of T'ung-t'ing lake, I-yang being the chief center. The ore is hand-picked at the mines and is brought by boat to Changsha, the center of the antimony trade in China. Here the ore is liquated and the regulus sent to Hankow to be either refined or exported in the crude state. During 1908 there was a notable decrease in the export of ore and a corresponding increase in the export of crude antimony.

The government refining plant near Wuchow, established early in the year 1908 to treat ore coming from the western part of the province near Sze-ch'êng, has proved a failure. This was due to the distance of the works from the mines and the consequent cost of transport, and to the poor quality of the refined antimony.

(By T. T. Read.)—There was little change in the antimony situation in China during 1909. The marked effect which the establishment of the modern works at Changsha had upon the production of regulus in 1908 still continues, but there has been little increase in the total production, the still incomplete returns for 1909 indicating an output almost exactly equal to that in 1908. Practically all of the production comes from Hunan, although there is a certain amount of ore exported from Canton and Wuchow. Most of the regulus exported has hitherto gone to France, Germany and the Netherlands, but in 1908 exports to the United States, which had previously been very small, increased until they exceeded those to any other country. Prices were not as high in 1909 as during the previous year.

After China, France is next in importance as a producer of antimony. Her supplies of raw ore are maintained by local mines and in particular by those of the Auvergne mountains, shipments from Australia and China. England levies toll on China, Australia, Japan and Canada for antimony ore. Italy mines and smelts ore from its own deposits while Germany is in a similar position to the United States, producing much hard lead and but little straight ore. In Mexico, a smeltery for the production of star antimony was installed at Wadley on the National Railroad, in the northern part of San Luis Potosi about 1900 and practically all of the Mexican ore is now treated there and shipped abroad as metal. The smeltery is controlled by the Cookson interests, which also have mines or contracts at Charcas, and Catorce in San Luis Potosi, and control the most important antimony deposits in other parts of Mexico. Most of the Mexican production is from mines controlled by this interest, as but very low prices are offered for independent ores. Recently several German buyers have appeared in the Mexican field and American interests were attracted there before the Payne tariff increased the rate of duty on antimony ore.

The accompanying tables show the output of ore and metal in the principal producing countries since 1896.

THE PRINCIPAL SUPPLIES OF ANTIMONY ORE. (*a*)

(In metric tons.)

	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
Austria	864	679	410	201	126	18	41	103	1,673	1,071	910	193
Bolivia	....	....	1,213	1,174	190	126	59	7	17	571	....	....
Canada (*f*)	*Nil.*	1,118	(*d*)	6	219	13	128	87	340	1,425	2,048	134
China (*e*)	....	....	....	....	....	....	....	....	....	3,624	2,382	544
France & Algeria	5,466	4,571	7,592	7,963	9,867	9,715	12,380	9,065	12,543	18,567	25,200	26,216
Hungary	1,800	2,201	1,965	2,373	323	748	205	1,080	949	580	2,035	1,316
Italy	2,150	1,931	3,791	7,609	8,818	6,116	6,927	5,712	5,083	5,704	7,892	2,825
Japan	348	1,006	712	81	119	88	153	104	96	97	....	....
Mexico (*b*)	5,873	5,932	10,382	2,313	5,103	1,279	1,856	1,775	2,035	2,418	4,615	4,046
N. S. Wales (*c*)	172	84	332	252	90	57	13	111	394	2,490	1,780	119
New Zealand	10	....	....	5	30	....	....	....	....	....	....	5
Portugal	417	245	59	38	126	68	83	31	84	481	383	76
Queensland	....	....	41	....	....	....	....	*Nil.*	24	*Nil.*	*Nil.*	42
Spain	354	130	50	30	10	67	42	245	77	180	205	124
Turkey	400	(*d*)	1,173	267	224	(*e*)481	(*e*)1,903	(*e*)298	(*e*)188	(*e*)1,036	....	....
United States	454	(*d*)	544	300	100	*Nil.*	*Nil.*	*Nil.*	*Nil.*	267	190	326

(*a*) From official reports of the respective countries. (*b*) Export figures, except for 1903, which represents production. (*c*) Metal and ore. (*d*) Not reported. (*e*) Exported. (*f*) Exports for the fiscal year ending June 30, except for 1906 and 1907 when figures represent production for the calendar year.

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES.
(In metric tons.)

	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
Austria	425	343	271	153	114	24	14	36	90	*Nil.*	207	162
China (*b*)	......	......	......	......	......	......	......	......	......	3,829	2,316	9,356
France	1,033	1 226	1,499	1,573	1,786	1,725	2,748	2,116	2,396	3,433	3,945	3,850
Hungary (*a*)	523	855	940	846	706	683	732	1,007	756	1,322	841	......
Italy	404	380	581	1,174	1,721	1,574	905	836	327	537	610	345
Japan	823	235	229	349	429	528	434	321	190	627	248	198

(*a*) Regulus. (*b*) Exports of regulus and refined metal.

The principal antimony refiners in England are Cookson & Co., of Newcastle-on-Tyne, Hallett & Fry, Johnson & Matthey, and Pontifex & Wood, of London; in France, E. Beau, in Alais (Gard), E. Chatillon and V. Geraud, in Brioude (Haute Loire), and the Herrenschmidt company at Le Genest (Mayenne); in Italy, the Société Anonyme Franco-Italienne, of Genoa, an important paint and metal producing company which has affiliations in France. In Bohemia and Hungary there are also several important refiners.

Progress in the Metallurgy and Determination of Antimony.

In a discussion and criticism of the various forms of the volatilization process a comparison of the relative merits of the Chatillon and Herrenschmidt processes is scarcely warranted. Both methods are economically successful under good management and both lack, by a great measure, perfection. Chatillon relies largely on condensation by water, in towers and scrubbers; Herrenschmidt condenses the major part of the fume in dry settling flues and chambers, and catches the last remnants of antimony by passing the gases through a centrifugal washer, which at the same time induces the draft. Both are experimenting with textile filters, and are using the organ-pipe settling-chamber system. We have no knowledge of the relative efficiency of the two types of furnace.

The new Chatillon furnace[1] is very attractive. A special feature is the double shaft, each section having two compartments, one placed directly above the other. In the upper compartment, most of the volatilization of the stibnite and fritting of the gangue is accomplished. On leaving this chamber the charge drops into the lower compartment, heating the air in its indirect passage to the top of the upper compartment and perfecting the volatilization of the antimony, so that the scoria which is withdrawn contains 1 per cent. and less of the metal. Since the Auvergne furnaces work best with an excess of air, the second chamber should act as a valuable economizer in heating the draft. With an excess of air, the

[1] *The Mineral Industry*, XVII, 42.

reduction of the higher oxides by SO_2 is less likely to be accomplished and consequently there will be less sulphuric acid formed to harm the condensing system. The disadvantage of using an excess of air lies in the fact that Sb_2O_4 and Sb_2O_5 are more likely to be formed than the desired Sb_2O_3 which condenses easily and makes an excellent paint. Furthermore, even with a warm blast the use of an excess of air reduces the temperature at the top of the furnace and in this way helps in condensing the oxide fume.

The high recovery attending the use of the volatilizing process has confirmed the belief which we have expressed of the relative ease with which antimony fume may be condensed. Nor must we allow the success accompanying the use of the spraying system of condensation in France to tempt us to apply the same methods to the recovery of lead and silver in the fume, for these last metals cannot be condensed with the same ease. At the same time methods for the recovery of antimony will probably never be perfected until some form of permanent textile filter is used to complete the Chatillon and Herrenschmidt systems. In the *Revue de Chimie Industrielle,* Professor M. Carbonelli deplores the fact that no bag filters can be economically used in the Italian works on account of the corrosive action of the gases and more especially of sulphuric acid. We wonder whether Carbonelli has tried the very strong and acid-resisting asbestos-thread bags in operation in his own neighborhood at Genoa. Mr. Herrenschmidt uses ordinary duck bags, but does not tell us what life they have and I believe that M. Chatillon, after trying them, abandoned the use of textile filters.

M. Carbonelli condemns the Italian practice, which is very similar to French methods, on account of the poor recovery effected, due to the foul character of the scoria.

I do not believe that this criticism applies to the slags produced in the French smelteries, and the difference in the recovery in the two countries is undoubtedly due to the character of the gangue of the ore. The French ore has a gangue of quartzite, the Italian ore, one of calcite. Consequently, at the temperature produced in the Italian furnaces, the shafts of which are much higher and the blast pressure correspondingly greater, calcium antimonite and possibly calcium antimonate are formed, occluded in the semi-fused scoria, and drawn off with the slag at the bottom of the shaft. M. Carbonelli also criticises the temperature used as unnecessarily high, thus increasing the difficulty of recovering the fume. He suggests two ways of overcoming the difficulties. The first is by mixing the French and Italian ores in proper proportions. In this way a calcium silicate slag would be formed in which the antimony would have less chance to be occluded in the form of calcium combinations. The drawback to this proposal is the expense of shipping the quartzite ore to Italy. His second proposal is to separate mechanically, as far as possible, the antimony sulphide from the limestone gangue and distil the former in a muffle. This seems to me an expensive alternative to the use of the shaft furnace. I suppose M. Carbonelli has some good reason for not suggesting the admixture of gold-bearing silicious material with the calcareous ore smelted at the Italian works.

M. Chatillon has recorded an improvement in his shaft furnace. His former practice was to charge the ore and coke through a number of cast-iron pipes which were about 4 or 5 ft. long, and thus by carrying the charge almost to the top of the burden in the shaft to eliminate the possibility of the fine ore being carried out of the neck by the draft. He now makes these pipes, preferably of fire clay, very much larger and carries them down to the center of the chamber. The antimony sulphide trickles out and is volatilized in the chamber, while the scoria is withdrawn through the grill.

While it is probably true that the French processes offer a larger recovery and greater ease of manipulation than any of the various methods, such as smelting in the blast, reverberatory and crucible furnaces which are used in Hungary and Bohemia, some data as to the character and working costs of the latest forms of English practice would be valuable information to the profession.

The English continuous process consists in (1) smelting a bath of ferrous sulphide in the hearth of a reverberatory furnace; (2) dropping the auriferous antimony sulphide into this and rabbling rapidly and thoroughly so that the ore is well intermixed with the bath; (3) adding wrought-iron scrap in sufficient quantity to precipitate metallic antimony when the temperature is kept fairly high; (4) tapping the antimony from the sump of the furnace until ferrous sulphide appears. The ferrous sulphide takes up the precious metals and is tapped from time to time.

In another method the ore, ground and screened to ½-in. size, is placed with the necessary wrought-iron scrap in a crucible and lowered into a furnace. The fluxes, consisting of about 10 per cent. of common salt and some skimmings from a previous smelting operation, are dropped into the crucible and the whole thoroughly digested at a fairly high temperature. Four fusions of 48 ℔. each are made in 12 hours. The metal reduced in the crucible is poured into a covered mold. It is about 90 per cent. pure, containing 7 per cent. of iron and 1 per cent. of sulphur, and is resmelted in the crucibles with pure antimony sulphide and salt.

This second charge consists of 84 ℔. of first crucible metal, 8 ℔. of sulphide of antimony and 4 lb. of salt. The fusion and reaction are helped by rapid stirring. The composition of the metal poured from the second crucible is 99.5 per cent. antimony, 0.2 per cent. iron and 0.16 per cent. sulphur. In order to produce "star" ingots, this metal is melted with a flux consisting of three parts of potash and two parts of ground liquated sulphide of antimony. In pouring the metal, it is essential that the slag and regulus should be poured together. If the antimony should run out alone into the mold, a slag of potash and antimony sulphide is poured over the top of it to insure the "starring" of the surface. The antimony which is volatilized is collected in the form of oxide and mixed with a new charge to be smelted in the crucible.

In the separation of antimony from argentiferous lead produced in the blast furnace, considerable progress has been made and it is probable, when the market price warrants it, that a process will be used to recover antimony regulus from the alloy. This process is carried out on the principle that, when a blast-furnace base bullion containing lead, silver, antimony and possibly bismuth, is melted and brought into contact with a greater quantity of hot liquid litharge floating on a bath of molten lead the antimony is oxidized at the expense of the oxygen in the litharge, while the bismuth and silver are completely absorbed by the lead bath beneath the litharge. The process consists (1) in melting a bath of lead in a magnesite-lined reverberatory furnace; (2) driving the surface of the molten lead into litharge by means of air supplied through blast pipes placed on either side of the fire bridge; (3) holding the liquid litharge, in the incipient stage of the process, at a high temperature; (4) in adding the bars of blast-furnace bullion or alloy at the fire-box end of the bath, while a constant blast is maintained. As each bar is added it is driven during the process of melting toward the slag doors which are on the end farthest removed from the fire bridge. In their course, the antimony of the bars is converted into antimony oxide by combining with the oxygen of the litharge; the greater part of the lead in the bar is also oxidized; the silver and bismuth are absorbed by the metallic lead underlying the litharge, while the proper portion of oxygen to maintain the thin layer of lead oxide is provided by the blast. A bar is completely decomposed before reaching the slag tap, so that as bar after bar is added at the fire bridge a steady stream of beautiful blood-red slag runs continuously over the breast into pots. Once the stream of bars is fed to the bath it will be found unnecessary to keep the fire going, for the reaction of the antimony and lead in the pigs with the oxygen of the litharge develops sufficient heat to maintain the required temperature. Herein lies one of the economical features of the process.

The antimony and lead of the alloy are oxidized in almost the same proportion as that in which they exist in the pig. The antimony, however, will be somewhat concentrated. For example, if we add bullion containing 70 per cent. lead and 15 per cent. antimony the resulting slag drawn off will contain about 75 per cent. lead oxide and a little more than 20 per cent. antimony oxide. It is not advisable to allow the layer of litharge to become more than a few millimeters in thickness. The slag is free from silver and the process may be continued until the bath becomes so rich in bismuth, gold and silver that economy will dictate the tapping of the rich metal for cupellation in a separate furnace. However, the rich metal may, if the furnace be constructed with such an object in view, be cupelled in the original furnace.

The process of obtaining the antimony in the lead in such condition that it may be marketed, consists either in making hard lead by smelting in the usual way in a blast furnace or in making regulus. This latter is accomplished by separating the lead by fractional reduction, assisting and maintaining the oxidation of the antimony by the judicial use of air and alkali salts. The antimony slag may be drawn and reduced to metal in the usual way, or ground and dissolved to be used in the manufacture of paint.

Wet Methods.—Every year witnesses the patenting or publication of a number of wet methods of recovering antimony. The temptation to develop such processes is especially strong on account of the relative ease with which the various and beautiful pigments such as the trioxide, the red sulphide and the brown oxysulphide, may be produced. The trioxide Sb_2O_3 is itself of excellent color, fire and covering capacity, while the mixture of barium sulphate and antimony trioxide which is obtained on adding barium carbonate to a hot solution of antimony oxide in sulphuric or sulphurous acid is of equal value. Of the leading three white metallic paints, white lead, white antimony and zinc white, white antimony has the greatest covering capacity and the most pleasing appearance.

Many patents have been granted for processes of making the yellow, brown and red sulphide paints. The old methods consisted in decomposing the alkali sulphantimoniates with sulphuric or hydrochloric acid. The reactions which took place are expressed in the following equation: $Ba_3Sb_2S_8+3H_2SO_4=3BaSO_4+3H_2S+Sb_2S_5$; $Ca_3Sb_2S_8+6HCl=3CaCl_2+3H_2S+Sb_2S_5$.

L. Brunet suggests utilizing the SO_2 obtained in volatilizing sulphides in the following way: Antimony oxide is dissolved in a sodium sulphide solution producing sulphantimonate of soda. This solution is sprayed or allowed to trickle through a Glover tower against a current of SO_2 gas from the sulphide furnace, when sodium sulphite, antimony pentasulphide, and hydrogen sulphide are produced. Colors of varying degrees of intensity from yellow to red may be obtained by adding sulphur during the precipitation of the pentasulphide.

E. Mathieu Plessy suggests the following process for making the bright vermillion variety of antimony sulphide: Chloride of antimony is made by boiling the native sulphide in hydrochloric acid. The clear antimony chloride solution which results on standing is decanted and diluted with water until it has a density of 25 deg. B. Four liters of this solution, six liters of water and 10 liters of 25 deg. B. hyposulphite of soda solution are then mixed. The oxychloride which instantly forms is dissolved by the hyposulphite and the solution is warmed gently to promote formation of the sulphide. At about 30 deg. C. orange-yellow sulphite begins to precipitate and at 55 deg. C. the precipitation is complete and the solution is allowed to cool. The mother liquors are decanted, and the bright red precipitate washed first with acidified, and then with ordinary water. The wash water is removed by filtration and the precipitate dried when it loses somewhat in the brilliancy of its color. There should be a large market in America for this useful and beautiful paint. Readers are referred for further information to German patent No. 172,410, June 28, 1905, and to *Bulletin,* Société Industrielle de Mulhouse, Vol. XX to XXVI.

White antimony may be made for the paint trade by dissolving the trioxide, which is sometimes sold for a pigment, in sulphurous or sulphuric acid and adding calcium, barium or strontium carbonate or hydroxide, when the double precipitate of antimony oxide and barium, calcium or strontium sulphite or sulphate is effected.

The most generally used alkali salt is barium carbonate. On this being added to the hot acid solution of the antimony trioxide, CO_2 is driven out and the barium-antimony paint precipitated. An economical method pursued in France consists in distilling the stibnite in a shaft furnace, collecting the fume by water sprays, recirculating the water until it acquires such a density from SO_2 that it readily dissolves the trioxide of antimony, and then precipitating by the addition of barium carbonate. The resulting paint is known in the trade under the name of lithopone of antimony.

Nicolle proposes to make pigment[1] as follows: Into a solution of barium sulphantimonite a stream of SO_2 is passed, whereupon a precipitate of barium thiosulphate ($Ba_2S_2O_3$) and antimony pentasulphide

[1] French pat. No. 390,617.

(antimony yellow) forms. To the liquid, saturated with sulphurous acid gas, sodium sulphate is added until the solution is free from $BaSO_4$. The solution is filtered off from the orange-colored barium-antimony pigment which has been precipitated, and the filtrate may be either evaporated to give sodium thiosulphate or treated with antimony chloride to produce antimony vermilion (anhydrous sulphide of antimony).

Messrs. Brunet, Chatillon and Genton have all patented methods of making the white and colored pigments. Messrs. Savigny and Doixami propose[1] the following method: 100 parts of Sb_2O_3 and 36 parts of sodium carbonate are mixed and heated for two or three hours. After cooling the mass is finely powdered, mixed with sulphur and alkali sulphide and boiled with water. The solution obtained is heated with an acid, and the orange-red precipitate of sulphur-bearing antimony sulphide is dried carefully at 40 or 50 deg. C. The color of the precipitate varies greatly with the quantity of sulphur added.

A process for recovering antimony regulus from the sulphide which is produced by treating ore tailings or slimes with caustic soda and precipitating the sulphide with sulphuric acid has been patented[2] by John Roy Masson, of Victoria, Australia. The precipitate of antimony sulphide is mixed with lean sand and chloridized by a stream of gas. The antimony chloride is washed out and cement antimony obtained by precipitation with iron or other electro-positive metal.

Uses.—In addition to its wide use in the form of alloys and pigments, antimony salts are applied in the forms of the trioxide for making enamels, of the trichloride in bronzing iron, of the trisulphide in pyrotechnics, of the pentasulphide in vulcanizing and coloring rubber and of the chromate (Naples yellow) in the ceramic arts. Many of its salts are also valuable medicines.

Bibliography of Antimony in 1909.

In reviewing the recent literature on antimony, the book[3] of the Chinese metallurgist, Chung Yu Wang, should receive first mention. This work of 217 pages treats of the history, chemistry, mineralogy, geology, metallurgy, uses, preparations, analyses, production, and valuation of antimony and antimony ores, and contains complete bibliographies. An article entitled "Note sur la Valeur des Minerais d'Antimoine,"[4] by M. Loiret given an elaborate treatment of the methods of valuing antimony ores and products.

---

[1] French pat. No. 361,380, April 15, 1905.
[2] U. S. pat. No. 890,432.
[3] "Antimony," London, 1909; Charles Griffin & Co., Ltd.
[4] *Ann. des Mines*, Dec., 1909, 582-608.

A voluminous bulletin by Eugen Weckwarth entitled "El Antimonio en el Peru"[1] was inspired by the active exploitation of the antimony deposits of Peru during the boom in that metal. This work treats not only of local ores, the production of which amounted to 300 tons during 1907, but also of the mineralogy, chemistry, metallurgy and prices of the ores.

An extract of Professor Hind's report on the Prince William mine, New Brunswick, with a description of the property and operations of the Canadian Antimony Company, Ltd., was published in the *Industrial Advocate,* Feb., 1909. D. F. Haley contributed an article[2] on the auriferous antimony ore of West Gore, Nova Scotia. One of the interesting features described is the milling operation which effects a saving of 80 per cent. of the antimony and gold at an estimated working cost of $2 per ton of ore treated. The mill has handled both mine ore and low-grade material from the dump, so that we must consider the results unusually satisfactory. From low-grade antimony ores such a recovery is seldom effected, owing to the laminal character of stibnite. The geological conditions of the deposit and the methods of mining and crushing the ore are fully described.

Chemical Determination of Antimony.—L. A. Youtz[3] has investigated the purity and volatility of antimony sulphide, precipitated in the usual way from a hydrochloric acid solution of the antimony salt. Notable quantities of chlorides were found in all his tests. These chlorides were not reduced by tartaric acid or by dissolving the antimony sulphide in ammonium sulphide and re-precipitating with acetic acid. Quantitative results are, however, attainable despite the presence of the chloride since there is but slight difference in molecular weight between SbOCl, $Sb_4O_5Cl_2$, and Sb_2S_3.

The perfect and beautiful method devised by A. E. Knorr and described by Walter C. Smith[4] should be the means of overcoming the difficulties of the antimony determination. Mr. Knorr's method of distillation in a specially constructed apparatus requires delicate manipulation, but amply rewards care and patience in making the determination.

A volumetric method of determining antimony in ores free from copper is described by Messrs. Coolbaugh and Betterton.[5] The ore is fused with ammonium persulphate and the cooled mass extracted with hydrochloric acid and water. Sulphuretted hydrogen is passed through the solution, and the washed precipitate dissolved in concentrated hydro-

[1] *Boletin* del Cuerpo de Ingenieros de Minas del Peru, No. 68.
[2] *Eng. and Min. Journ.*, LXXXVIII, 723.
[3] *Journ.* Am. Chem. Soc.
[4] *Eng. and Min. Journ.*, LXXXVIII, 1062.
[5] *Chem. Zeit.*, Sept. 14, 1909.

chloric acid with addition of potassium chlorate. The liquor is filtered and a small quantity of ferric chloride added to the filtrate. The ferric salt is reduced by the addition of stannous chloride until the yellow color of the ferric chloride disappears. After cooling, 10 c.c. of saturated mercuric chloride is added and the solution, diluted to 500-600 c.c. is titrated with permanganate. Silver, lead, bismuth and arsenic do not interfere with the titration, but a correction must be made for the iron added. The ferric chloride serves as an indicator in adding the stannous chloride, which does not reduce the iron until all the antimony is in the "ous" condition.

ARSENIC.

By Frederick W. Horton.

The domestic output of arsenic was increased during 1909 by the advent of a new producer, the United States Smelting Company, which started its arsenic plant at Salt Lake City, Utah, to treat the baghouse product of its lead smeltery. The Brinton Arsenic Mines Corporation, whose plant at Brinton, Va., had been closed for a considerable period, also resumed operation. The other producers in this country are the Everett plant of the American Smelters Securities Company, at Everett, Wash., and the Anaconda Copper Mining Company, at Anaconda, Mont. The accompanying table gives the domestic output of arsenic in the United States since its production began in 1901, and imports and consumption dating back several years further.

STATISTICS OF WHITE ARSENIC IN THE UNITED STATES.

Year.	Production.			Imports.			Consumption.	
	Pounds.	Value.	Per lb.	Pounds.	Value.	Per lb.	Pounds.	Value.
1897	....	....	....	7,242,004	$352,284	$0.05	7,242,004	$352,284
1898	....	....	....	8,686,681	370,347	0.04¼	8,686,681	370,347
1899	....	....	....	9,040,871	386,791	0.04¼	9,040,871	386,791
1900	....	....	....	5,765,559	265,500	0.04¾	5,765,559	265,500
1901	600,000	$18,000	$0.03	6,989,668	316,525	0.04½	7,589,668	334,525
1902	2,706,000	81,180	0.03	6,110,898	280,055	0.04½	8,816,898	361,235
1903	1,222,000	36,691	0.03	7,146,362	256,097	0.03½	8,368,362	292,788
1904	996,456	29,504	0.03	6,391,566	226,481	0.03½	7,388,022	255,985
1905	1,545,400	50,225	0.03⅓	6,444,083	219,198	0.03⅓	7,989,483	269,423
1906	1,663,000	83,150	0.05	7,639,507	336,609	0.04½	9,302,507	419,759
1907	2,020,000	101,000	0.05	9,922,870	553,440	0.05½	11,942,870	654,440
1908	2,603,505	99,193	0.03¾	9,592,881	417,137	0.04⅜	12,196,387	516,330
1909	2,015,880	57,957	0.02⅞	7,183,644	272,493	0.03¾	9,199,524	330,450

With the exception of the output of the Brinton Arsenic Mines Corporation, which mines and treats arsenopyrite especially for its arsenic content, the arsenic produced in the United States is essentially a by-product derived from the treatment of flue dusts obtained in the smelting of arsenical gold, copper and lead ores. On this account production was not materially affected by the low prices which prevailed during 1909. The output of the Everett plant is largely obtained from auriferous arseno-sulphide ores, coming from California, Washington and British Columbia, and is supplemented by a smaller amount derived from flue dust shipped from Montana and Utah smelteries. At the

Washoe plant[1] of the Anaconda Copper Company, the quantity of arsenic fumes made in smelting is enormous. At present only a very small proportion of this is saved, but it is estimated that if even one-half of the arsenic were recovered this plant alone could more than supply the total domestic consumption. At the plant of the United States Smelting Company the fumes from the lead furnaces are neutralized by the use of lime and zinc oxide, and the gases are then passed through the baghouse where the dust and condensed arsenic fumes are filtered out. The material collected by the bags is removed by means of mechanical bag shakers and falls into cellars beneath. After attaining a depth of six to eight inches the material is fired and burned to a clinker, which is shoveled out and treated in Brunton furnaces to obtain a product of refined arsenic.

During 1909 the Boston & Montana Copper Company, at Great Falls, Mont., installed a frictional system for fume and dust recovery at a cost exceeding $1,000,000. This plant[2] will recover enormous quantities of arsenic, but it was completed too late in 1909 to figure as a producer during the year. The greater part of the arsenic consumed in the United States was imported from Europe, some also coming from Canada and Mexico.

Market and Prices.—Arsenic was quoted at the beginning of 1909 at $2\frac{7}{8}$@3c. per lb. There was a slight advance during January and February, when the manufacturers of paris green and other insecticides were making their final purchases. In March and April the price receded to about 2.7c., but there was a rally during the succeeding months, especially in June and July. This was largely the result of speculation as to the adoption of a duty on this product. It was still left on the free list by the Payne tariff and the price dropped to about $2\frac{7}{8}$c., with some quotations for large lots as low as $2\frac{5}{8}$c. During the fall months the demand improved to some degree, owing to better trade conditions in the glass industry. The market, however, failed to respond and sales continued at $2\frac{5}{8}$@$2\frac{3}{4}$c. The price was steady during the remainder of the year and closed at $2\frac{7}{8}$c.

In 1909 a new low level of prices for recent years was established and the entire position of the arsenic industry underwent a change. The domestic producers, by selling at an unusually small profit, wrested control of the American market from the European interests, who heretofore largely dominated the local situation. Legislation preventing the free exhaustion of arsenic fumes into the atmosphere, has resulted in the

[1] *Trans.* A. I. M. E., XXXVII.
[2] *Eng. and Min. Journ.*, LXXXIX, 368.

erection of arsenic plants at several of the western smelteries and as these smelters were willing to dispose of their arsenic at very little above the cost of transportation, domestic consumers received the benefit. The year 1910 will undoubtedly see a large increase in domestic production and pending an exceptional increase in consumption, high-priced arsenic would seem to be a thing of the past.

Arsenic in Foreign Countries.

The principal foreign countries producing arsenic are, in the order of their importance, Germany, France, United Kingdom, Spain, Portugal, Canada and Mexico.

Canada.—The total Canadian output of white arsenic in 1909 was 2,248,945 lb., valued at $67,468. There were three producing companies—The Canadian Copper Company at Copper Cliff, Ont., the Deloro Mining and Reduction Company at Deloro, Ont., the Coniagas Reduction Company at St. Catharines, Ont. In addition to the output of arsenious acid these smelteries exported speiss and residues containing 1,074,511 lb. of arsenic. This was all obtained from Cobalt ores. Arsenic exports for 1909 were 3,111,249 lb., valued at $119,673. The production of white arsenic in 1908 was 1,431,000 lb., valued at $41,060, and of arsenical ore and concentrates, 986 tons, valued at $17,506.

China. (By T. T. Read.)—Arsenic in China is not an especially important product, and the amount produced in 1909 shows a marked decrease from the output in 1908, probably due to bad market conditions. All the production comes from Hunan province. In 1908 it amounted to nearly 5000 tons and in 1909 to only about 400 tons.

Germany.—In 1909 Germany imported 1348 metric tons of arsenic ore, valued at 121,000 marks. Over one-half of this ore came from China. Imports of white arsenic were 834 metric tons, valued at 375,000 marks and exports were 1003 metric tons, valued at 552,00 marks.

Spain.—The output of arsenical pyrite in Spain in 1908 was 5533 metric tons, valued at $22,163; 2004 metric tons of white arsenic, valued at $115,032, were also produced. Badelona and Ribas were the principal points of manufacture.

United Kingdom.—Arsenopyrite is mined in Cornwall, Devon and Carnarvon. In 1908, 3218 tons of ore, valued at £3931, were produced. More than one-third of the quantity obtained in Devon was the result of reworking old dumps. There were nine arsenic refineries in operation. These produced 1936 tons of white arsenic, worth £19,190.

Mexico.—The Compañia Minera de Peñoles at Mapimi, Durango, is the principal producer in Mexico.

WORLD'S PRODUCTION OF ARSENIC.
(In metric tons.)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1896	*Nil*	2,632	320	6	....	271	3,674	....	....
1897	*Nil*	2,987	200	13	524	244	4,232	....	....
1898	*Nil*	2,677	215	7	751	111	4,241	....	....
1899	52	2,423	304	5	1,083	101	3,890	....	2,600
1900	275	2,414	120	5	1,031	150	4,146	....	4,705
1901	630	2,549	....	10	527	120	3,416	272	7,491
1902	726	2,828	....	12	736	71	2,165	1,226	5,372
1903	233	2,768	50	6	698	1,088	916	554	6,658
1904	66	2,829	80	4	1,370	400	992	452	3,117
1905	*Nil.*	2,535	....	8	1,562	1,140	1,552	701	3,627
1906	*Nil.*	3,052	....	5	1,322	1,114	1,625	754	6,534
1907	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908	649	2,822	451	20	1,655	2,004	2 007	1,301	2,381
1909	1,020	(c)	(c)	(c)	(c)	(c)	(c)	914	(c)

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore.

Bibliography of Arsenic in 1909.

With the exception of the following articles on the determination of arsenic the literature of the year contained little of importance.

Andrews, L. W. and Farr, H. V. "The Volumetric Determination of Small Amounts of Arsenic." (*Am. Journ. Sci.*, April, 1909; 5 pp.)

Bensemann, R. "Qualitativer Nachweis und Quantitative Schätzung geringer Mengen Arsen." (*Zeit f. angew. Chem.*, Sept. 10, 1909; 1¾ pp.)

Brown, T. "The Determination of Arsenic and Antimony in Ores." (*Mex. Min. Journ.*, March, 1909; 1 p.)

Hooper, H. E. "A Rapid Method for the Estimation of Arsenic in Ore." (*Bull.* 41, I. M. M.)

Parry, L. "The Assay of Arsenic and Antimony." (*Min. Journ.*, July 31, 1909; ½ p.)

Smith, W. C. "Separation of Arsenic and Antimony by Means of the Knorr Distillation Apparatus." (*Eng. and Min. Journ.*, Nov. 27, 1909; 1¼ pp.)

ASBESTOS.

By Frederic W. Horton.

The production of asbestos in the United States in 1909 surpassed that of any previous year. The output of the Canadian mines, from which consumers in the United States obtain approximately 90 per cent. of their supply, was the largest in their history, but due to an unsatisfactory demand actual shipments were less than in 1908. The Lowell Lumber and Asbestos Company, Lowell, Vt.; the Sall Mountain Asbestos Company, 438 Broadway, New York (operations at Sall Mountain, Ga.), and the Spokane Asbestos Fire Brick Company, Spokane, Wash. (mines at Kamiah, Idaho), were the only producers in the United States. Of these the first company was the only one mining chrysotile fiber.

ASBESTOS STATISTICS OF THE UNITED STATES.

Year.	Production.			Imports.		
	Short Tons.	Value.	Value per Ton.	Manufactured.	Unmanufactured.	Total.
1897	840	$ 12,950	$15.42	$10,570	$264,220	$ 274,290
1898	885	13,425	15.17	12,899	287,636	300,535
1899	912	13,860	15.20	8,946	303,119	312,068
1900	1,100	16,500	15.00	24,155	331,796	355,951
1901	747	13,498	18.08	24,741	667,087	691,828
1902	1,010	12,400	12.27	33,313	729,421	762,734
1903	(a) 887	(a) 16,760	(a) 18.90	32,058	657,269	689,327
1904	(a) 1,480	(a) 25,740	(a) 17.40	51,290	700,572	751,862
1905	3,100	126,300	40.74	70,117	776,362	846,479
1906	(a) 1,695	(a) 28,565	(a) 16.85	96,162	1,010,453	1,106,615
1907	950	11,700	12.32	200,371	1,104,110	1,304,481
1908	1,350	24,000	17.78	147,548	1,068,342	1,215,890
1909	4,025	87,625	21.77	240,381	(b) 993,254	1,233,635

(a) Statistics of the United States Geological Survey. (b) 46,507 short tons.

In the Caspar Mountain district, Natrona county, Wyo., active work in developing the chrysotile asbestos deposits was carried on by five companies. The North American Asbestos Company and the Wyoming Consolidated Asbestos Company began the erection of mills for treatment of their rock and installed part of the nceessary machinery. Both companies expect to commence production in the summer of 1910. The International Asbestos Mills and Power Company and the Hall Asbestos Company are planning the erection of mills, but, together with the United States Asbestos Mining and Fiberizing Company, confined themselves to development and prospecting work in 1909. The Caspar Mountain district is one of much promise and within a few years may furnish a substantial output.

Prices.—As a direct result of over-production in the Canadian mines prices weakened considerably. According to the Department of Mines, Canada, the average price of crude No. 1, f.o.b. mines, in 1909 was $270.37, as compared with $300.59 per ton in 1908. The average price of crude No. 2 dropped from $165.38 to $152.11 per ton; of No. 1 mill stock from $80.54 to $53.18 per ton; and of No. 2 mill stock from $29.33 to $24.70 per ton. The price of No. 3 mill stock advanced 8c. per ton to $9.37 while the average price of asbestic dropped 1c. to 73c. per ton.

Asbestos in Foreign Countries.

Outside of Canada, whose mines furnish 75 per cent. of the world's supply of asbestos, the producing countries in order of their importance are Russia, the United States, British South Africa, Portuguese East Africa and Cyprus.

Africa.—In 1908 British South Africa exported 1605 tons of asbestos, valued at $108,250, an average price of $67.40 per ton. During the first six months of 1909 the exports were 1056 tons as compared with 718 tons during the same period of the previous year. The total production of 1909 probably exceeded 2000 tons. The principal output was in the Carolina district, Cape Colony, where the Carolina Asbestos Company is the chief operator. For the year ending Sept. 30, 1909, this company produced 207 tons of asbestos, 37 per cent. of which was fiber one inch and over in length. The company has no mill, and recovery is effected by cobbing, sorting and screening by hand. It is estimated that at least 35 per cent. of the asbestos content of the rock is lost in the fines; but these are carried to a separate dump where they will be available for mechanical treatment later on. The exportation of asbestos from British South Africa began in 1902, when 45 tons, valued at $70 per ton, were shipped. The Transvaal and South Rhodesia contributed to the production for the first time in 1908. For the year ended June 30, 1909, the asbestos production of the Transvaal was valued at £7400. A syndicate operating in the Victoria district, Rhodesia, reports having mined from August, 1908 to March, 1909, about 120 tons of first grade fiber, which was exported to England, and about 100 tons of lower grade fiber, which was stacked on the property awaiting a time when it could be handled at a profit. The Rhodesian production in 1909 amounted to 272 tons as compared with 55 tons in 1908.

According to British Government returns, imports into the United Kingdom from Portuguese East Africa amounted to 1599 tons in 1908. The material was very high grade and was valued at $173.20 per ton.

The high average price of the African exports indicates that only the superior grades of fiber were marketed. This is to be expected, since the industry is not sufficiently established to be provided with mills and machinery necessary to produce the lower grade material, such as paper stock. The entire African production is marketed in Europe.

Canada.—Asbestos is mined in the Eastern townships of Quebec at Black Lake, Thetford, East Broughton and Danville. The event of special interest in the Canadian asbestos industry in 1909 was the consolidation of a number of the larger producers to form the Amalgamated Asbestos Corporation, Ltd., with a capitalization of $25,000,000. The companies consolidated were Kings' Asbestos Mines, Thetford; the Beaver Asbestos Company, Thetford; the British-Canadian Asbestos Company, Ltd., Black Lake; the Standard Asbestos Company, Ltd., Black Lake; the Dominion Asbestos Company, Ltd., Black Lake, and the Bell Asbestos Mines, Thetford, the last by a contract covering production in excess of that required for manufacturing purposes by the owners. This merger gives the Amalgamated corporation control of approximately 70 per cent. of the total Canadian output. In December, 1909, the corporation employed 1400 men and hoisted about 2500 tons of rock per day. Electric power for the operation of its mines is furnished by the Shawinigan Water and Power Company on long-term contracts at $28 per h.p. year. In 1909 the latter company extended its transmission line from Thetford to East Broughton, where it will supply most of the power used.

Closely following the consolidation effected by the Amalgamated corporation the Black Lake Consolidated Asbestos Company was formed, with a capitalization of $5,000,000. One important result of the promotion of this company was the reopening of the Union mine and the adjoining Southwark property at Black Lake. The Consolidated company commenced the construction of a mill to serve both these mines. In 1909 the Berlin Asbestos Company, operating near Broughton, constructed four miles of railway to connect its properties with the Quebec Central Railway and built a mill. The Beaudoin and Audit Company opened mines at Robertson. At East Broughton, a 300-ton mill costing $175,000 was completed on the Frontenac property. At Thetford, the Jacobs Asbestos Company reopened its mines and commenced the erection of a mill. Considerable development work was carried on at the new Clarke mine and at the Demers property. All the large mines at Thetford were in operation throughout the year and night work was inaugurated at the Kings' Asbestos Mine of the Amalgamated corporation, searchlights being employed to illuminate the pit, an innovation which was also introduced by the Asbestos and Asbestic Company at Danville. The last-named company erected a new mill in 1909, thereby increasing its milling capacity 50 per cent.

Throughout the district there was an unprecedented activity in effecting consolidations, building mills, opening up new properties and in general development and prospecting work. Production showed a correspondingly large increase amounting for the year to approximately 75,600 tons valued at about $2,968,171. Shipments, however, were less than in 1908, indicating no advance in trade requirements. The total shipments in 1909 were as folows: Crude, 3074 tons ($575,510); mill stock, 60,275 tons ($1,709,071); total asbestos, 63,349 tons ($2,284,587); asbestic, 23,951 tons ($17,188); total products, 87,300 tons, valued at $2,301,775. For 1908 total shipments amounted to 90,773 tons, valued at $2,573,335, showing a decrease in the 1909 shipments of 3199 tons or 4.8 per cent. The stocks on hand Dec. 31, 1909, were about 20,920 tons, valued approximately at $1,179,679 as compared with stocks on hand Dec. 31, 1908, of 8669 tons valued at $596,095.

STATISTICS OF ASBESTOS IN CANADA. (*a*)
(In tons of 2000 lb.)

Year (*b*)	Production. (*b*)				Exports (*c*)		Imported
	Asbestos.		Asbestic.				
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Value.
1897	13,202	$ 399,528	17,240	$45,840	10,969	$ 510,916	$ 19,032
1898	16,124	475,131	7,661	16,066	18,424	510,368	26,389
1899	17,790	468,635	7,746	17,214	14,520	453,176	32,607
1900	21,621	729,886	7,520	18,545	18,164	490,900	43,455
1901	32,892	1,248,645	7,325	11,114	26,715	864,573	50,829
1902	30,219	1,126,688	10,197	21,631	33,072	1,131,202	52,464
1903	31,129	915,888	10,548	13,869	30,661	955,405	75,465
1904	35,635	1,167,238	13,011	13,006	34,636	984,836	83,827
1905	50,670	1,486,359	17,594	16,900	41,127	1,311,524	116,836
1906	59,283	1,970,878	20,127	17,230	59,864	1,689,257	138,000
1907	62,018	2,482,984	28,519	22,059	56,753	1,669,299	200,371
1908	66,548	2,555,361	24,225	17,974	59,051	1,730,755	191,204
1909	63,349	2,284,587	23,951	17,188	59,732	1,758,057	181,710

(*a*) From *Annual Reports* of the Geological Survey of Canada, the *Statistical Year Book* of Canada, the *Report* of the Department of Mines of Canada, and the *Report* of the Department of Customs, Canada. (*b*) Production is given for calendar year; exports and imports are for fiscal years ending June 30 up to and including 1907. In 1908 and 1909 the fiscal year ended March 31. In 1908 and 1909 figures of production represent quantities sold or shipped. (*c*) Mainly crude asbestos. (*d*) Manufactured articles entirely.

Cyprus.—A concession to mine asbestos in the Troodos Hills of Cyprus has been held by an Austrian company since 1907. Under the terms of its license from the Government the company was bound to export during the first year of its operation a minimum of 75 tons of asbestos. Up to April 1, 1909, it exported 457 tons, on which a royalty of 10 per cent. was paid to the Government. The company is making further importations of machinery and there is every prospect of its becoming a substantial and steady producer.

Russia.—The latest available data for the annual production of asbestos in Russia is for 1907, when 10,331 tons were produced. On account of the heavy cost of transportation the quality of fiber marketed is generally very high. In 1908 the portion of the Russian output exported to the United Kingdom was valued at $118.20 per ton. The principal asbestos deposits are in the Ural mountains, in the province of Perm and in the Altai mountains of Siberia. In the Yenisei district, in the vicinity of Krasnoyarsk and Minusinsk, and at Bachti, Kuldsha, Dsharkent and Tashkent, south of the Altai mountains, there are valuable deposits undeveloped except by the primitive workings of the natives. In 1908 rich deposits of asbestos rock were discovered in the Urenburg in the Orsk district. The fiber is of the chrysotile variety and occurs in large veins of serpentine, intersecting various schists and porphyries. The veins are visible at the surface and vary from 350 to 2100 ft. in length. The South Ural Asbestos Company has rented the properties on which the deposits occur for a period of 40 years and has erected a mill for treatment of the rock which is said to have an average content of 15 per cent. asbestos. It is lately reported that the Uralite Company, operating in the Ekaterinburg district, has sold six of its asbestos mines on the Berezoff and Monetnoi Treasury estates to the recently formed Italo-Russian Asbestos Company, which proposes to work them on a large scale. The entire output of Russian asbestos is marketed in Europe. The prices received vary, according to quality, from 90 kopeks (46c.) to 4.7 rubles ($2.42) per pood (36.97 lb.), f.o.b. at the mines.

Other Countries.—In New Zealand, asbestos is found in small pockets and veins in the serpentine of the Pounamu formation. It is often of very fine quality, but as yet no deposits of sufficient extent to be commercially workable have been discovered. Late reports from Queensland state that a considerable deposit of asbestos has been discovered at Little River, near Porter's Retreat in that country, but just how important the find may be is not known. Asbestos is produced at several places in Japan, especially in Kiushiu, but the material is of very poor quality, and when used alone is not suitable for manufacturing purposes. Foreign material is, therefore, imported for admixture with the local product. The most important manufacturer of asbestos in Japan is the Japan Asbestos Company, at Osaka.

Use of Asbestos.

In 1909 the chief development in the use of asbestos was along the line of fireproofing, the use of asbestos paper between floors, for lining walls, etc. Paper stock for the manufacture of these materials was in such demand that the trade took approximately 70 per cent. of the total mill product. Textiles manufactured from long fiber asbestos also came into more general usage. There was a large increase in the demand for high-pressure packing, and for the first time asbestos brake-band linings for automobiles were used. These linings are made of asbestos cloth interwoven with fine copper wire and treated with special frictioning compounds. Another notable application of asbestos is the recent use of the finely ground material as a pigment under the name "Asbestine." Used in moderate quantities in a paint, this pigment imparts many desirable qualities.

ASPHALTUM.

By Frederick W. Horton.

In 1908 there was a marked decrease in the production of asphaltum, related bitumens and bituminous sandstone in the United States as compared with the output of the previous year. The reduction in tonnage was accompanied by a still greater decline in the value of the output; these recessions being apparently due to depressed trade conditions. According to statistics of the U. S. Geological Survey the production in 1908 amounted to 185,352 short tons, valued at $1,888,881, as compared with 223,603 short tons, valued at $2,826,481, in 1907. The accompanying table gives statistics of domestic production according to States.

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (*a*)
(Tons of 2000 lb.)

States.	1906			1907			1908		
	Tons.	Value.	Per Ton	Tons.	Value.	Per Ton	Tons.	Value.	Per Ton.
Bituminous Sandstone.									
California	20,418	$47,427	$2.32	34,531	$84,016	$2.43	27,118	$91,998	$3.39
Kentucky	1,629	7,330	4.50	6,993	33,397	4.77	10,253	54,823	5.35
Oklahoma (*c*)	738	2,029	2.75	4,002	11,627	2.90	....	....	....
Arkansas	900	5,400	6.00	....	....	....	....	....	....
Georgia (*f*)	400	8,500	2.13	....	....	....	....	....	....
Total	24,085	$70,686	(*g*)$2.93	45,526	$129,040	(*g*)$2.83	37,371	$146,821	(*g*) $3.93
Asphaltum (*b*)									
California	71,539	711,150	9.94	96,537	1,129,941	11.70	104,873	1,218,696	11.62
Oklahoma (*c*)	*Nil.*	....	....	70	1,400	20.00	116	3,480	30.00
Missouri	*Nil.*	....	....	(*i*)4,650	42,500	9.15	....	....	....
Texas	24,993	307,952	12.32	53,649	929,857	17.33	17,167	350,440	20.42
Total Asphaltum	96,532	$1,019,102	(*g*)$10.55	154,906	$2,103,698	(*g*)$13.58	122,156	$1,572,616	(*g*)$12.87
Gilsonite (*d*)									
Utah	12,947	159,600	12.33	20,719	569,440	(*h*) 27.48	19,033	100,324	5.27
Oklahoma (*c*)	1,952	16,432	8.42	966	7,743	8.03	2,286	20,340	8.90
Mastic									
California	*Nil.*	....	....	*Nil.*	....	....	3,250	36,563	11.25
Kentucky	2,543	24,158	9.50	1,744	16,568	9.50	1,286	12,217	9.50

(*a*) From the Mineral Resources of the United States. (*b*) Includes hard and refined, or gum, liquid or maltha, and oil residues. (*c*) Indian Territory included before amalgamation into one State. (*d*) Includes gilsonite, elaterite, grahamite, ozokerite and "tabbyite." (*f*) First reported separately in 1906. (*g*) Average value per ton. (*h*) The average value of the gilsonite alone was only $26.22 per ton. (*i*) Partly from Kentucky.

No deposits of natural asphalt in sufficient quantity to warrant exploitation have been found in the United States. Residual or oil asphalts derived from California and Texas petroleums form the bulk of the domestic supply. Maltha and bituminous sandstones are next in value while gilsonite (including elaterite, grahamite, ozokerite and tabbyite) is of least importance. The production of gilsonite is, however, rapidly increasing; the output of the Uinta reservation in Utah in 1909 amounting to about 28,000 tons. With the completion of the Moffat railroad through this section the industry will assume still more important proportions.

Gilsonite is used for street paving, roofing and similar purposes. Elaterite, or mineral caoutchouc, an elastic bitumen, was also produced in some quantity. Elaterite is used for roofing, and by mixing it with other hydrocarbons, a mineral rubber is being manufactured from which a Salt Lake company is successfully making automobile tires.

In 1909, a complete asphalt plant was installed at the Standard Oil refinery at Richmond, Cal., and the manufacture of asphalt brick, intended primarily for paving, was commenced. These bricks are made of a mixture of asphaltum and sand and are rolled in lime to prevent them from sticking together when stacked or during transportation. When the lime is washed off and the bricks laid upon a properly prepared foundation they soon become stuck together, forming a practically continuous pavement.

Imports of asphaltum and bitumen into the United States in 1909 amounted to 148,744 short tons, valued at $646,655, as compared with 147,685 short tons, valued at $587,698 in 1908. The greater part of the imports came from the island of Trinidad. Venezuela (Bermudez), Mexico, Cuba, Germany and Italy were the other important sources of supply. Exports of foreign asphaltum from the United States were 7691 short tons, valued at $48,375 in 1909, and 4773 short tons, valued at $21,419 in 1908.

Asphaltum in Foreign Countries.

France.—The output of asphaltic rock in France in 1908, amounting to 171,000 metric tons, valued at $261,901, was derived from 18 mines. The production consisted of 124,000 metric tons of bituminous schist, 41,000 metric tons of asphaltic limestone and 6000 metric tons of "boghead." There are two important districts in which mining of the schist is carried on: In the basin of Autun, in the department of Saône-et-Loire, which produced 66,000 metric tons, and that of Aumance, in Allier, which produced 57,000 metric tons. Asphaltic limestone is mined in the departments of Ain, Gard, Puy-de-Dôme and Haute-Savoie.

Germany.—The production of asphaltum in Germany is not sufficient to supply the domestic demand and large quantities are imported. The production in 1908 was 89,009 metric tons, and imports in the same year amounted to 130,062 tons. In 1909 the total imports were 98,377 tons, of which Italy supplied 61,828 tons; Switzerland, 10,538 tons; British America, 17,315 tons, and the United States, 3753 tons. The price of asphalt in Hamburg in 1909 ranged from $21.42 to $28.58 per ton, according to grade.

Japan.—In 1908 Japan produced 2409 metric tons of asphalt valued at $72,114.

Mexico.—Exports of asphaltum from Mexico in 1908 amounted to 5692 metric tons. Of this quantity, 2022 tons went to Great Britain, 1996 tons to Belgium, 1323 tons to Germany, and 391 tons to the United States.

Venezuela.—Bermudez asphalt forms the bulk of the Venezuelan production. In March, 1909, the asphalt beds near Guanoco were reopened, and from July to December, 17,000 metric tons, valued roughly at $5 per ton, were shipped to the United States. Mining operations at the Inciarte asphalt deposits on the Rio Limon, in the Lake Maracaibo region, were also resumed, but no shipments were made.

The accompanying tables give the output of asphalt and bituminous rock in the principal producing countries.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK. (*a*)
(In metric tons.)

Asphalt.

Year.	Germany.	Hungary.	Italy (*c*)	Spain.	Trinidad(*b*)	United States.	Total.
1900	89,685	2,900	33,127	2,331	161,299	8,326	297,668
1901	90,193	2,878	31,814	4,182	173,707	19,882	322,656
1902	88,374	2,773	33,684	6,034	167,253	36,923	335,041
1903	87,454	2,422	35,757	4,675	196,883	54,521	381,712
1904	91,736	2,221	34,227	3,463	137,089	77,250	345,986
1905	115,267	247	26,838	5,805	116,735	68,935	333,827
1906	138,059	4,111	34,386	6,229	132,381	94,316	409,482
1907	126,649	3,920	38,568	8,643	(*d*)147,051	161,783	486,614
1908	89,009	4,818	34,761	9,231	(*d*)136,583	134,273	408,675

Bituminous Rock.

Year.	Austria.	France.	Italy.	Spain.	United States.	Total.
1900	887	266,000	101,738	4,193	41,029	413,847
1901	541	250,000	104,111	3,956	37,393	396,001
1902	897	258,000	64,245	6,301	35,072	364,515
1903	1,273	243,000	89,690	6,277	37,334	377,574
1904	1,435	277,000	111,390	3,761	19,454	363,040
1905	4,363	191,509	106,586	5,725	32,337	340,520
1906	2,840	196,375	130,825	7,794	21,848	359,682
1907	3,858	177,000	161,126	8,219	41,301	391,504
1908	3,695	171,000	134,163	12,373	33,902	355,133

(*a*) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland and Venezuela are not available. (*b*) Exports. (*c*) Including mastic and bitumen. (*d*) For the year ending Jan. 31.

Bibliography of Asphaltum in 1909.

In an article[1] entitled "Bitumen and Oils in West Africa," T. Hugh Boorman describes the occurrence of asphaltum in Nigeria and gives tables showing the comparative composition of crude and refined asphalt and the ultimate composition of pure bitumen from the asphalts of Trinidad, Bermudez and Nigeria. H. W. MacFarren describes[2] the occurrence of ozokerite in Utah and outlines the methods employed in extracting the mineral from its gangue. In an article[3] entitled, "Hydrocarbons in the United States," Arthur Lakes reviews the occurrence of asphaltum and related bitumens in this country and gives a detailed description of several of the more important deposits of gilsonite, elaterite, etc., together with data as to cost of production, prices, etc. The geological occurrence and mining of asphaltum in France is outlined by F. A. Ionides.[4] An editorial in *Ideal Power,* VI, 291, describes the Mariel asphalt mines in Cuba.

---

[1] *Eng. and Min. Journ.*, LXXXVII, 1037.
[2] *Min. and Sci. Press*, XCIX, 789.
[3] *Min. Science*, LX, 340.
[4] *Ibid.*, LIX, 244.

BARYTES.

By Albert H. Fay.

During the years 1907 and 1908, the barytes business in the United States had a hard struggle for existence and there was no marked improvement during 1909. This was largely due to the fact that the foreign product could be imported at a price much lower than the cost of the domestic article.

STATISTICS OF BARYTES IN THE UNITED STATES.

Year	Production.			Imports.				Consumption.	
	Short Tons	Value.		Crude.		Manufactured.			
		Per Ton.	Total.	Sh. Tons.	Value.	Sh. Tons.	Value.	Sh. Tons.	Value.
1897	26,430	$4.00	$105,720	502	$ 579	1,300	$13,822	28,232	$120,121
1898	28,247	4.00	112,988	1,022	2,678	687	8,678	29,956	124,344
1899	32,636	4.20	137,071	1,739	5,488	2,111	22,919	36,486	165,478
1900	41,466	3.90	161,717	2,568	8,301	2,454	24,160	46,488	194,178
1901	49,070	3.22	157,844	3,150	12,380	2,454	27,062	54,674	197,286
1902	58,149	3.21	186,713	3,929	14,322	3,908	37,389	65,986	238,424
1903	(a)50,397	3.02	152,150	6,344	22,777	5,716	48,726	62,457	223,653
1904	(a)65,727	2.66	174,958	6,689	27,463	5,920	48,658	78,336	251,070
1905	53,252	3.68	196,041	7,879	36,796	4,827	39,803	65,418	272,649
1906	63,486	3.98	252,719	9,189	27,584	4,808	37,296	77,483	317,599
1907	65,579	3.83	251,308	18,344	77,683	10,006	96,542	93,929	425,533
1908	38,546	3.38	130,409	12,197	58,822	3,037	29,168	53,780	218,399
1909	39,831	3.54	138,634	12,422	35,387	2,240	19,320	54,493	193,338

(a) Statistics of the U. S. Geological Survey.

Industrial Conditions and Prices.—One of the depressing features was the agitation of the pure paint law which made it compulsory for the paint manufacturers to label all paint packages with the formula of the contents. North Dakota was the first State to enact this law, and it immediately resulted in a decrease in the sale of paint containing barytes. The absurdity of some of the paint bills became apparent, and official reports on paint tests had a quieting effect on the legislative action. During the winter and spring, the volume of business was fair, but in the latter part of the year it improved materially, so that the total result was about normal. The addition of an import duty of 75 cents per ton on the foreign raw products has had a stimulating effect on the domestic mineral. A duty of $5.25 per ton was also placed on the ground material imported from foreign countries. The great drawback, however, with the barytes industry in the United States is the fact that the majority of the deposits are so far from manufacturing centers that the freight rate makes it an easy matter for foreign material to compete with the domestic products. Again, the foreign mineral is a purer and whiter material. The imports were confined largely to the crude material.

As heretofore, the principal demands were from the paint and rubber manufacturers. Although these demands were covered by contracts which were drawn on from time to time, considerable new business developed, and the general tone was firm. In the local market, prevailing quotations on bleached barytes remained unchanged throughout the entire year as follows: $18.50@22.50 per ton for foreign prime white, $16@17 for domestic, and $12.50@15 for off grades, f.o.b. New York.

Barytes Mining in the United States.

Connecticut.—There is no barite mined in Connecticut. The plant of Hammill & Gillespie at Stamford, operated the entire year on imported raw material. This concern grinds and bleaches the natural mineral. No attempt is made to produce artificial salt of any character.

Georgia.—There are good deposits of barite near Cartersville. Many of these occur in connection with the ocher deposits above a quartzite formation. The ocher deposits have been worked for many years. It is only within the last few years that any attention has been paid to the barite deposits, active work having begun in 1907. While the quality of the mineral is good, the deposits are so far from industrial centers that freight rates almost prohibit its being placed on the markets. The principal operators in this district are Nulsen, Klein & Krausse of St. Louis, Mo., and John T. Williams & Son, Bristol, Tennessee. The output of the district during 1909 is reported as 2000 short tons.

Kentucky.—Barite deposits occur in a number of counties among which may be mentioned Boyle, Jessamine, Mercer, Owen and Scott. These deposits have been made a subject of investigation by the State Geological Survey, and much field work has been done by F. J. Fohs. The Dix River Barytes Company kept its mine running in a small way during a portion of the year. The crude material was sold to the Kentucky Barytes Company at Nicholasville, Kentucky. The output of the State for the year did not exceed 1000 tons.

Missouri.—As usual Missouri produced almost three-fourths of the barite mined in the United States. The deposits are in Washington county and most of the shipments were made from stations on the Iron

Mountain railway, from 45 to 60 miles southwest of St. Louis. The principal producers in the district are the Point Milling and Manufacturing Company at Mineral Point; Nulson, Klein & Krausse, St. Louis, and James Long, of Potosi.

The barite occurs over an area of about 100 sq.m., one-tenth of which contains workable deposits. Under the present system of open-cut mining a productive field produces about 600 tons per acre when worked to a depth of 8 ft. It is estimated that there are approximately 4,000,000 tons of barite available by the present mining methods. About 400 miners, besides those engaged in hauling the rock to the railroad, are supported by this industry. Most of the mineral is dug from residual clay deposits and practically none, except when worked in connection with lead, is taken out below the water level. The royalty ranges from 50c. to $1 per ton, depending upon the contract the operator is able to make with the land owner. The standard price for crude barite delivered at the railroad station is $4@4.10 per ton. The price paid at the mine ranges from $1.75@2.75 per ton, depending upon the quality of the rock. The majority of the deposits are off the railroad, and the item of wagon haulage is an important one.

Open-pit mining with pick, shovel and wheelbarrow still prevails. All the freighting is done by farm wagons. One company attempted to use a traction engine and went into bankruptcy. Another company attempted to work the deposits hydraulically, but this method failed on account of not having a sufficient supply of water to carry away the tailings. The steam shovel has been considered as a means of effecting a lower mining cost, but it is hardly feasible on account of the small tonnage of barite required to stock the market. So long as labor remains as cheap as it is in this section, it is not likely that any important improved methods of mining will be introduced. According to figures obtained from the railroad company's records, the district produced a little over 28,000 tons of crude barytes.

New York.—Crude barite is not produced in this State. Most of the product from New York is from mills which import mineral principally from Nova Scotia. The Barium Production Company of New York City, with a plant at Barren Island, went into the hands of a receiver late in 1909 after operating only a few months.

North Carolina.—The Carolina Barytes Company was the only large producer in the State during the year. The mill is at Stackhouse on the French Broad river. The mines are two or three miles from the railroad and connected with the mill at the railroad by means of a narrow-gage tramway. The cars are operated by horses. The mill is equipped for grinding the crude rock, and only a small portion of the company's output is shipped in the raw state. The raw material produced in North Carolina in 1909 is reported as between 8500 and 9000 tons.

Tennessee.—The barytes industry of the State was practically at a standstill in 1909. W. D. Gilman & Co. at Sweetwater mined in a small way, and operated a plant in which a limited amount of barium carbonate was produced. The Commercial Mining and Milling Company of Knoxville was idle all year, but is making preparations to resume operations early in 1910. The plant of John T. Williams & Son at Bristol was idle most of the year, undergoing important changes in the methods of grinding and bleaching. Experiments were conducted on the manufacture of various barium salts.

Foreign Countries.

England.—An important deposit of barite was recently discovered in North Wales. This occurs in a Carboniferous limestone in which lead ores have been mined for many years. In addition to the barite which occurs in this deposit there is also a quantity of the carbonate (witherite) which is rather an unusual occurrence. The sulphate is entirely free from lime, and contains about 99 per cent. barium sulphate. Fluorspar also occurs in connection with the barite deposits.

The supplies of the sulphate and carbonate minerals are being more freely drawn upon, and Continental consumers are turning their attention to the United Kingdom, both as to mining and buying. The difficulties of securing needed supplies of high-grade sulphate are causing prices to advance slightly, and the Harz mountain firms are finding it difficult to supply outside consumers. The United Kingdom, Canada and America are freely inquiring, and the mines producing the best mineral have no trouble in finding a market.

In the County of Durham, the County of Durham Barytes Company, Ltd., has spent a large amount of money in opening up mines and building extensive mills with up-to-date plants to handle barytes and has already established agencies in the home, Continental and Canadian markets. Barite is becoming more difficult to procure free from impurities of iron and lime. The color and barium percentage are rarely obtainable combined in such a way as to suit the several markets. Bleached barite does not suit the chemical industries, on account of the sulphuric acid employed. Both home and Continental demands are increasing, due to new methods and the demands in the chemical trade.

Germany.—A good quality of white barite is found in the Thuringian and Harz mountains, which is ground and placed on the market without bleaching. Only a small amount of this is imported, as the German producers find it more profitable to grind it. The deposits of the Rhine district are 100 to 150 in number. They are shallow and usually worked from the surface as open cuts or quarries. The marketing of barytes is particularly difficult because of its extreme cheapness, rendering railroad shipment of the crude mineral impossible; while, on the other hand, the rivers by which it is shipped to seaboard are frequently frozen in winter, or dry in summer, to which may be added the fact that many of the mines are frozen in winter and spring, and flooded in summer. The innumerable small quarry owners doing business in out-of-the-way places are seldom able to make favorable freight contracts, and hence always quote prices delivered at the mine or nearest railroad station. A few of the quarries are found near large rivers. There are almost as many mills in Germany as there are mines or quarries, usually in the vicinity of the latter, and most of these are operated by water power which is only available during part of the year. The barite of the Rhine district is usually dark and is much inferior to that from the Harz. It is from this district that the principal imports are made.

Foreign buyers of German barytes find it almost impossible to establish direct relation with producers or millers, and the trade is mostly in the hands of special middlemen, exporters and shippers. The entire skill in the exporting trade and the profit to the exporter as well, depend upon making a favorable freight contract, as the freight and shipping expenses are much more than the cost of the mineral. German barytes delivered at the mines fluctuated between $1.19 and $1.66 per ton. The crude material was quoted in the New York market in June, 1909, as follows: Absolutely white, $5.25@5.50; slightly grayish, $4.75@5; more grayish, $4.25@4.50, which is exclusive of a duty of 75 cents per ton. The manufacturer of paints prefers to pay this duty and receive a special quality rather than handle the domestic crude goods which yield an inferior color and quality.

Nova Scotia.—Barytes deposits occur about two miles north of Five Islands, Nova Scotia, a village 12 miles east of Parsborro, on the north shore of Minas basin. These deposits were recently described before the Geological Society of America, by C. H. Warran. The barite is coarsely crystalline and remarkably pure. It occurs in the form of large, irregular vein-like masses, stringers, and smaller isolated bodies in an old fault breccia. It also occurs as a filling in fissures, sometimes several feet wide. The breccia is part of an extended zone of faulting which lies in a narrow east-west band of folded Devonian slates and quartzite. The fault zone follows the contact with intrusive syenites which form the core of the hills. Near the eastern end of this fault zone, north of Londonderry, barite also occurs associated with iron ore. The barite is believed to have resulted from a leaching and concentration process which took place through the agency of water percolating downward along a zone of faulted and broken rock. The adjoining country rock contains about 0.2 per cent. barium oxide. A comparison with deposits elsewhere leads to the conclusion that many barite deposits are the result of a concentration of the barium content of limestone, sandstone, and quartzite, wherever faulting or crushing has made an easy channel for circulating waters.

Tasmania.—A deposit of barite was opened in 1908 by W. H. Taylour on the northeast flank of Mt. Darwin. The samples obtained are of a good quality. A large deposit of high-grade mineral is reported on Howards Plains, within one mile of the Mt. Lyell company's office.

Austria.—During 1909 Austria imported 13,939 metric tons of crude barite and exported 2585 tons. The bleached material imported amounted to 237 tons, and the exports, 34 tons.

Manufacturers of Barium Products.—In the following table are given the names and addresses of all the consumers and producers of crude barytes in the United States that are known to us:

Name.	Address.	Operation.
Nulsen, Klein & Krausse Mfg. Co	St. Louis, Mo	Bleach, grind, float.
Finck Mining and Milling Co	St. Louis, Mo	Bleach, grind.
Point Milling and Manufacturing Co	Mineral Pt., Mo	Bleach, grind, float.
Nulsen, Klein & Krausse Mfg. Co	Lynchburg, Va	Bleach, grind.
Pittsburg Baryta and Milling Corp	Richlands, Va	Bleach, grind.
Commercial Mining and Milling Co	Knoxville, Tenn	Bleach, grind.
William D. Gilman Co	Sweetwater, Tenn	Crush, jig, roast, salts.
John T. Williams & Son	Bristol, Tenn	Bleach, grind, roast, salts.
Carolina Barytes Co	Stackhouse, N. C	Bleach, grind.
Hot Springs Mfg. Co	Hot Springs, N. C	Bleach, grind.
Delaware Barytes and Chemical Co	Dover, Del	Bleach, grind, salts.
Dix River Barytes Co	Danville, Ky	Bleach, grind.
Hammill & Gillespie	Stamford, Conn	Bleach, grind.
Cawley, Clarke & Co	Newark, N. J	Lithophone.
N. Z. Graves & Co	Philadelphia, Pa	Lithophone.
Harrison Bros. & Co	Philadelphia, Pa	Lithophone.
Excelsior Mfg. Co	Newport, Del	Lithophone.
Grasselli Chemical Co	Grasselli, N. J	Lithophone.
New Jersey Zinc Co	Palmerton, Penn	Lithophone.
Cheeseman Chemical Co	Scranton, Pa	Lithophone.
Becton Chemical Co	Becton, N. J	Lithophone.
American Paint and Pigment Co	East Alton, Ill	Roast, salts.
E. E. Dwight & Co	Webb City, Mo	Roast, salts.
Krebs Pigment and Chemical Co	Newport, Del	Lithophone.
Kentucky Barytes Co	Nicholasville, Ky	Grind and bleach.
United States Barytes Co	Tiff, Mo	Crude ore.
Potosi Lead, Baryta and Mer. Co	Potosi, Mo	Crude ore.

Bibliography.—Various articles on barytes have been published in THE MINERAL INDUSTRY, giving statistics each year., In addition to the statistical feature, Vol. II gives a brief account of the history of the barytes mining industry. In Vol. VIII is a description of a process for making caustic baryta, and also a method for the determination of barium in barytes. In Vol. X is an account of the technology of barytes, including a process for the manufacture of barium oxide. In Vol. XIII is a discussion of the process of bleaching barytes and a history of the barytes industry 1887 to 1894, by W. D. Gilman. Vol. XIV gives a description of the Gilman plant at Sweetwater, Tenn. In Vol. XV, E. K. Judd reviews the industry in the United States, with notes on mining, milling, bleaching and roasting barytes. In Vol. XVI is an account of the barytes mining in Canada, by E. K. Judd, and notes on the mining and manufacture of barium products by Edwin Higgins. The geology, mining and preparation of barite in Washington County, Mo., has been described by A. A. Steel.[1]

[1] *Trans.* A. I. M. E., Spokane Meeting, 1909.

BAUXITE.

By Frederick W. Horton.

The production of bauxite in the United States in 1909 amounted to 90,325 long tons, valued at $475,110 as compared with 52,167 tons, valued at $263,968 in 1908. As in previous years, the bulk of the output came from Arkansas, the other producing States, Georgia, Tennessee and Alabama, ranking in the order given.

PRODUCTION OF BAUXITE IN THE UNITED STATES.
(In tons of 2240 lb.)

State	1899	1900	1901 (a)	1902	1903 (a)	1904	1905	1906	1907 (a)	1908 (a)	1909
Alabama	14,144	650	18,038	5,577	22,374	7,087	17,094	27,131	97,776 (b)	14,464	1,814
Georgia	19,619	20,715		19,000		16,909					33,515
Arkansas	3,050	2,080	867	4,645	25,713	24,016	30,897	51,200		(b)37,703	(b)54,966
Total	36,813	23,445	18,905	29,222	48,087	48,012	47,991	78,331	97,776	52,167	90,325

(a) Statistics of the United States Geological Survey. (b) Production of Tennessee included.

The chief producers of bauxite in this country are the Republic Mining and Manufacturing Company, 1111 Harrison building, Philadelphia, Penn., and the Aluminum Company of America, Pittsburg, Penn. (both companies operating mines in Alabama, Arkansas and Georgia), the National Bauxite Company, Rome, Ga. (mining in Georgia and Tennessee), John H. Hawkins, Rome, Ga., the Howard Hydraulic Cement Company, Chattanooga, Tenn., and the Cherokee Mining Company, also of Chattanooga (the last three operating in Georgia only). The major portion of the bauxite output is employed in the manufacture of aluminum. A large quantity is used in the production of aluminum sulphate, in the manufacture of bauxite brick and other refractories, and in the manufacture of the artificial abrasive alundum.

Industrial Conditions and Prices.—Notwithstanding an increased demand for bauxite, the importation of the mineral from France was nearly 4000 tons less in 1909 than in 1908. The average value of the imported material was $4.50 per ton. The ocean freight rate is approximately $2 per ton and the import duty is $1. The price of domestic bauxite ranged from $5 to $7 per ton.

Bauxite in the United States.

Alabama.—The mines at Rock Run in Cherokee county, were the only producers in the State in 1909. The Republic Mining and Manufacturing Company was the principal shipper. The production of the State has fallen off rapidly during the last three years, amounting to about 11,000 tons in 1907, 6000 tons in 1908, and only 1814 tons in 1909. The decline in production would seem to indicate that the mines are becoming exhausted. Bauxite is known to occur in Calhoun, Talladega, and DeKalb counties, but as yet the small amount of prospecting and development work done on the deposits has not shown them to be of commercial importance.

Arkansas.—The principal deposits of bauxite in Arkansas are in Saline and Pulaski counties. The Republic Mining and Manufacturing Company, and the Aluminum Company of America are the only operators. At the town of Bauxite, Saline county, the latter company has erected a crushing and drying plant, and owns and operates the Bauxite & Northern Railroad, connecting all of its mines in that locality with the Chicago, Rock Island & Pacific, the Missouri Pacific and Iron Mountain railroads. Allmost the entire bauxite production of the Stae is used in the manufacture of aluminum.

Georgia.—The output of bauxite in this State continues to come from Floyd, Bartow and Polk counties in the Georgia-Alabama district. Shipments were made from Halls, Cave Springs, Kingston, Shannon, Cunningham, Ætna, Six Mile, Rome and Hematite. The deposits in Wilkinson county, which were discovered early in 1908, although they appear to be of considerable promise, have remained undeveloped, and very little prospecting work has been done. This new field which is in no way connected, either geographically or geologically, with the deposits in northwestern Georgia, has been studied in detail by Otto Veatch, of the Geological Survey of Georgia.[1] The bauxite occurs in beds resting upon Cretaceous clays, or as nodules disseminated through the clays. The ore is commonly pistolitic or concretionary, but is also amorphous. It varies in color from a cream white to a bright red, and is generally hard. The genesis of the ore is obscure, but the presence of clays which, in their physical appearance and chemical composition, show a gradual gradation from bauxite to unaltered clay, would suggest an alteration process. Most of the bauxite mined in Georgia is used for refractory purposes, or in the manufacture of aluminum sulphate.

[1] *Bull.*, Geological Survey of Georgia, No. 18 430-447.

(By S. W. McCallie.)—There has been but little change in the bauxite industry since 1907. Considerable prospecting was carried on during 1909 both in the Rome and the Kingston districts. In the latter district a new plant was erected and operated for a short time by the Cherokee Mining Company, near Linwood, Bartow county. In the immediate vicinity of this plant a number of prospects have been located which give promise of yielding a considerable quantity of high-grade bauxite. Some prospecting during the year was carried on in the new bauxite field in Twiggs county, south of Macon, but no ore of any consequence has yet been put on the market from this district.

Tennessee.—The National Bauxite Company continued to work its mines on Missionary Ridge, near Chattanooga, and was the sole producer in this district.

Virginia.—A highly ferruginous pistolitic bauxite is found in Botetourt county, near Troutville, at the Houston iron and manganese mines. The bauxite occurs with iron and manganese ores in a bed of variegated clay resting on a partly decomposed sandstone. As the bed of clay is only from 15 to 30 ft. thick, the bauxite associated with it is merely a surface occurrence, and is unlikely to prove of any commercial importance.

CONSUMPTION OF BAUXITE IN THE UNITED STATES.

Year.	Production.			Imports.		Exports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1896	17,096	$42,740	$2.50	2,119	$10,477	....	....	19,215	$53,217
1897	20,590	51,475	2.50	2,645	10,515	2,537	$5,074	20,708	56,916
1898	26,791	66,978	2.50	1,201	4,238	1,000	2,000	26,992	69,216
1899	36,813	101,235	2.75	6,666	23,768	2,030	4,567	41,449	12,436
1900	23,445	85,922	3.66	8,656	32,968	1,000	3,000	31,101	115,880
1901	(a)18,905	97,914	4.25	18,313	66,107	1,000	3,000	36,218	144,021
1902	29,222	128,206	4.39	15,790	54,410	*Nil.*	....	43,112	175,875
1903	(a)48,087	171,306	3.56	14,889	49,684	*Nil.*	....	62,976	220,990
1904	48,012	166,121	3.46	15,475	49,577	*Nil.*	....	63,487	215,698
1905	47,991	203,960	4.25	11,726	46,517	*Nil.*	....	59,717	250,477
1906	78,331	352,490	(e)4.50	17,809	63,221	*Nil.*	....	96,140	415,711
1907	(a)97,776	480,330	4.91	25,065	93,208	*Nil.*	....	122.841	573,538
1908	(a)52,167	263,968	5.05	21,679	87,823	*Nil.*	....	73,846	351,791
1909	90,325	475,110	5.26	18,689	83,956	*Nil.*	....	109,014	559.066

(a) Statistics of the United States Geological Survey. (e) Estimated.

Bauxite in Foreign Countries.

Austria.—Bauxite occurs in the province of Istria, in the form of pockets in red sandstone. The district opened for prospecting is estimated to contain 300,000 tons of bauxite of good quality, and as the cost of mining is low, and transportaton cheap, the material can successfully compete with imported French bauxite. For a description of the deposit the reader is referred to a paper[1] by M. Polley.

[1] *Mont. Zeit.*, Jan. 15, 1909.

France.—The production of bauxite in France in 1908 amounted to 170,679 metric tons valued at $325,303, an average of $1.90 per ton. The output came principally from the department of Var, which produced 146,000 tons consisting mostly of red bauxite. Mining was also carried on in Hérault, Bouches-du-Rhône and Ariège, these departments supplying 10,000, 9359 and 5320 tons, respectively. The average red bauxite mined in France contains from 55 to 65 per cent. alumina, 1 to 5 per cent. silica, 2 to 3 per cent. titanic acid and 19 to 28 per cent. ferric oxide, and is the chief source of supply for the manufacture of aluminum. Of the white bauxite, there are two classes; the first, containing high alumina, not more than 4 per cent. iron, and practically no silica, is used in the manufacture of chemicals; the second, containing 45 to 47 per cent. alumina, as high as 28 per cent. silica and only traces of iron, is extensively employed in the form of bauxite brick in the construction of cupolas, glass furnaces, fire-box linings, etc. This last variety of white bauxite is mined at Villevyrac, the red bauxite principally at Var and all three classes at Baux. The amount of bauxite mined during the last five years has exceeded the tonnage shipped, and it is reported that the owners now have on hand, either in warehouses or at the mines, a stock of approximately 400,000 tons. In 1908 exports of bauxite from France amounted to 107,240 metric tons. Imports during the same period were 554 metric tons. The Continental American Ore Company, 33 Broad street, Boston, Mass., is the leading American agent for French bauxite.

Hungary.—Occurrences of bauxite have long been known at Remecz and Petrosz in Hungary, but deposits have recently been discovered farther west in the Bihar mountains where they occur in a Jurassic limestone which covers an area of about 106 square miles. The bauxite is found principally as superficial accumulations which represent the result of weathering (bauxite placers) but occasionally in the form of irregular lenses which are primary deposits. The amount of ore in sight is variously estimated from 5,870,000 to 18,700,000 tons. In regard to quality, the Hungarian deposits are in the first rank, an average specimen of ore containing alumina, 60 per cent.; ferric oxide, 24; titanic acid, 3; silica, 1.5; and combined water, 11.5. As water power is available within short distances, and the manner in which the bauxite occurs permits cheap mining, these deposits will, without doubt, prove of commercial importance. For a more detailed description covering the geology, occurrence and genesis of the ores, the reader is referred to the original paper.[3]

[3] *Zeit. für Prakt. Geol.*, XVI, 353-362.

India.—The occurrence of laterites (products of weathering characterized by the presence of free aluminum hydroxide) rich in alumina and resembling ordinary bauxite, have long been known in India. In 1905 the government of India, through the Geological Survey, undertook a special investigation of these deposits in order to determine whether or not they were of commercial importance. The result of this research showed that there was an enormous quantity of laterites in some of the central provinces which could be obtained by simple quarrying; that these laterites were rich in alumina (52-59 per cent.) and low in silica (0.05-2 per cent.) but contained a large amount of titanic acid (7-12 per cent.); that on account of this high titanic acid content and the cost of transport to coast ports and hence to the European markets, the Indian laterites could not meet he competition of French or even of American bauxites. It was suggested, however, that by the adoption of Bayer's process alumina could be extracted from the ore in India at a low cost, and could be sold at prices which would be remunerative to exporters. The paper[1] referred to gives a detailed account of the investigation together with analyses of samples, conclusions as to commercial value, etc. In 1908 the only production of bauxite in India was 32 long tons from the Punjab.

Italy.—There is only one mine producing bauxite in Italy. In 1908 the output from this property amounted to 7000 metric tons valued at $12,159, as compared with a production of 3500 metric tons valued at $6080 during the previous year.

The United Kingdom.—The entire bauxite production of the United Kingdom comes from County Antrim, Ireland, where the bauxite occurs in seams lying between sheets of Tertiary basalt. In 1908 the production amounted to 11,716 long tons valued at $14,720 as compared with an output of 7535 long tons valued at $9167 in 1907. The entire production in 1908 was made by three companies; the N. G. Stopford Company, Craigahulliar Mine, Portrush; the Bauxite Company, Ltd., Irish Hill Mine, Straid, and the Crommelin Mining Company, Ltd., Tuftarney Mine, Newtown. Alumina is prepared at works near Larne, County Antrim, and is then sent to Scotland for reduction.

Technology.

An improved method for extracting aluminum oxide from aluminous clays is described by Frank Moore in *Rev. de Chimie Industrielle,* January, 1909.

---

[1] *Bull.*, Imperial Institute, VII, 278-285.

Of the patents recently issued on the treatment of bauxite, the following are noted:

Alumina.—An improvement in the manufacture of alumina. Gilbert McCulloch, East St. Louis, Ill. (U. S. No. 941,799, Nov. 30, 1909; and No. 938,269, Oct. 26, 1909.)

Alumina.—Process of manufacture of alumina. A. Simon and L. Pernot. (French No. 405,135, Nov. 6, 1908.)

Alumina.—Process for the manufacture of pure alumina. O. Serpek. (French No. 404,923, July 9, 1909.)

Alumina.—Process of extracting alumina from bauxite. A. Simon and L. Pernot. (French No. 406,590, Dec. 10, 1908, and first addition thereto dated Jan. 23, 1909.)

Alumina.—Process for the electrolytic production of aluminum oxide. Frank W. Morris, Victoria, B. C. (Brit. No. 6449 of 1908.)

Ore Treatment.—Method of treating aluminum ore. Frank J. Tone, Niagara Falls, N. Y. (U. S. No. 929,517, July 27, 1909.)

BISMUTH.

By Kirby Thomas.

The production of bismuth from lead-bismuth bullion by the Betts electrolytic process, begun experimentally in 1907 by the United States Metals Refining Company at Grasselli, Ind., was carried on commercially during 1909 on a moderate scale. Certain smelting companies during 1909 openly entered the market to buy ores containing bismuth, particularly lead ores low in bismuth, and for the first time payment was offered for the bismuth content of gold and silver and other ores. The production of bismuth is, however, largely incidental to the production of other metals, and no operations in the United States are being carried on primarily and principally for the mining or recovery of bismuth.

During 1909 there was no reported export of bismuth ore from the United States. In 1908 exports of about 10 tons of ore higher than 25 per cent. bismuth and about 80 tons carrying 6 to 7 per cent. were made. The United States imports of the metal were higher in 1909 than in 1908, but not so high as in 1906 and 1907. The import statistics are shown in the accompanying table.

IMPORTS OF BISMUTH INTO THE UNITED STATES.

Year.	Pounds.	Value.	Av. per lb.
1896	124,263	$ 90,950	$0.73
1897	151,374	172,236	1.14
1898	137,205	162,846	1.19
1899	176,668	208,197	1.18
1900	180,433	246,597	1.37
1901	165,182	239,061	1.45
1902	190,837	213,704	1.12
1903	147,295	235,199	1.60
1904	185,905	339,058	1.82
1905	148,589	318,007	2.14
1906	254,733	318,452	1.25
1907	259,881	325,015	1.25
1908	164,793	257,397	1.56
1909	183,413	286,516	1.48

The import price reported is a little less than the established syndicate price of 6s. 6d., probably taking into account the metal grade. The sale of bismuth produced in the United States is controlled by the Powers-Weightman & Rosengarten Company of Philadelphia and New York and a ready demand for all the product at $1.67 per lb. is reported.

There is a continued export demand for bismuth ores from the United States. The price for the ore at New York is on the basis of 50c. per ℔. for the bismuth content for a 50-per cent. ore, with an inversely graded price for ores of less percentage. A very much higher price is offered for ore above 50 per cent. Copper, iron and arsenic in the bismuth ore is objectional. The copper limit in an ore carrying 25 per cent. or more is 10 per cent., and 2 per cent. in an ore of 6 per cent. or less. Up to 10 per cent. of iron is permitted. The arsenic should be below 12 per cent. in all cases.

Bismuth occurs in many places in the United States, particularly in the Rocky Mountain States. In Colorado, Leadville has yielded several shipments of complex ore carrying from 7 to 14 per cent. bismuth. A small lot was produced near Granite in 1908. The San Juan district has bismuth in some of the veins. In Fremont and Chaffee counties are several promising deposits of bismuth, with ore from 1½ to 3 per cent. Near Montezuma, native bismuth in small quantity has been extracted and in Gilpin county is a small vein with telluride of bismuth. From New Mexico several small shipments of ore from 11 to 25 per cent. have been made from the San Andreas Mountain section. Deposits near Mesa and Phoenix, in Arizona, have been exploited in a small way. Bismuth is found with the gold and silver ores at Goldfield, Nev., and a deposit in Churchill county, Nevada, is being investigated. Important deposits are proved in Beaver county, Utah, and at Deep Creek bismuth with gold and tungsten is reported. Float bismuth ore is found abundantly near the north end of Salt Lake. In Custer county, Idaho, a telluride of bismuth ore is found and bismuth in placer material is reported from Norris, Mont. The Lang deposit in San Bernardino county, California, has yielded several experimental lots and is reported to be extensive, but low in grade.

Mexico has produced some high-grade bismuth from the Mariposa mine in Sinaloa and from the Belen mine in Sonora. A shipment of complex ore with bismuth was made in 1908 from the Cananea district. The Rey del Bismuto mine in Sinaloa yields extensively an ore containing bismuth, 2 per cent.; iron, 33; silica, 31; alumina, 12.5; magnesia, 2; zinc, 1; copper, 0.9, with traces of lime, arsenic and sulphur and gold and silver. This property has recently been acquired by an American company and an extensive investigation of the treatment problem has been made by S. E. Bretheron.[1] A successful smelting operation with a charge of 10 per cent. lead and 2 per cent. bismuth, giving recovery of 80 to 90 per cent. bismuth is reported. Plans are being

[1] Smelting Bismuth-lead Ore, Sinaloa, Mexico, *Eng. and Min. Journ.*, April 9, 1910.

made for the regular operation of the property. Some rich oxidized bismuth ores have been extracted near Ojo Caliente, Chihuahua. Bismuth ocher occurs with the nickel-cobalt deposits in the Pihuao mine in Jalisco. Bismuth occurs in El Doctor mine in Queretaro, and with silver ore in the andesite in the Cerro del Carmen, Durango, the Sierra del Guanajuato and at Tamascaltepec. The Sauharipa district in Sonora promises to yield much bismuth when the completion of projected railroads permits of economic operations.

Bolivia continues to be the most important contribution to the world's bismuth supply. Aramayo, Francke & Co., Ltd., is the chief producer. In its report for 1909 this company stated that its Tasna mines continue to produce bismuth at a rate sufficient to supply the market and are in as good a condition as they have ever been. The same company has accumulated at its smeltery at Quechisla a lot of copper-bismuth matte, containing about 12 per cent. copper. Efforts have been made to devise an economical method for the treatment of this. Insofar as the copper is concerned the result of a bessemerizing process has been unsuccessful, but on the other hand the company states that it has been successful in establishing a system to extract the bismuth and is now able to get that metal from this matte at a lower cost than the bismuth obtained directly from the product of the mines. The sales of Bolivian bismuth in 1909 showed a large increase over 1908. The exports for the first nine months of 1909 are reported to have amounted to $110,029.

The Australian yield is not increasing. Queensland produced bismuth ore valued at £10,595 in 1908 and £2771 in 1909. The New South Wales output in 1909 was £1624 and the Tasmania product, £980. A chemical process for the treatment of the ore is being tried at one of the mines in New South Wales.

The European bismuth situation is unchanged. The German and English syndicated interests control the metal production and dominate the world's market under a division of territory program, and have maintained the price at 6s. 6d. since 1907. Several European countries produce bismuth ore, notably Germany, England, Austria-Hungary, Spain, and Italy. Some product comes from the saving of bismuth as a by-product from the treating of the base and precious metal ores sent to European plants.

The use of bismuth in the drug trade is reported to be increasing, as is also its industrial applications arising from the low-fusion property of its alloys. A large use is for low-temperature fusion plugs for the automatic sprinklers now extensively used for fire protection. Another use is for safety plugs for steam boilers. A new use in the electrical industry is being investigated, which promises to greatly increase the demand for the metal, particularly if it can be furnished at a lower cost.

In the article by Mr. Bretherton herein referred to are the following important contributions to the metallurgy of bismuth: "The question which naturally occurs is: Can the lead be cupelled from the bismuth as well as from the gold and silver? My assistant at the Rey del Bismuto made some experiments in the assay furnace with small cupels; on the strength of this statement and test, and my experience with a large cupel furnace in Leadville, Colo., and recently at Lodi, Nev., it was decided to put in a cupel furnace at Rey del Bismuto. I advised the construction of a suitable dust chamber and small baghouse, providing for the cooling if needed. Again referring to the bismuth and its distribution in the blast-furnace product, I found that it does not go into the matte as much as the lead, but it does pass off in the flue dust in greater proportion. For example, the bullion shipped contained 8.3 parts lead to 1.7 parts bismuth, while the flue dust carried only five parts lead to one bismuth and the matte contained 18.3 parts lead to one part bismuth. The proportion of bismuth to lead in the slag is uncertain. The slag averaged about 1 per cent. lead, the chemist often not finding more than a trace by the fire assay. His results, using a silver button in the crucible as a collector, when making a fire assay for lead, were no higher.

"In conclusion I think it is safe to say that 80 per cent. of the bismuth contained in a 2 per cent. ore (assay made by all wet method), and all the bismuth found by the combination fire and wet assay, can be recovered by lead smelting in the blast furnace, by using not less than 10 per cent. lead in the charge, and in connection with a suitable dust chamber and baghouse. Less bismuth in the ore would call for a smaller per cent. of recovery. A higher per cent. of recovery of the bismuth will result when the ore contains more than 2 per cent. bismuth. The combination method of making a bismuth assay (a fire assay by using excess lead as a collector and then dissolving the button for bismuth) averaged about 81 per cent. of the bismuth found by using all wet method. I consider that the blast furnace, under favorable conditions, will do equally as well as the combination method assay for bismuth. All the gold and silver, as shown by the assays, was recovered."

In *Mines and Minerals*, Sept., 1909, E. B. Wilson has a general technical article on bismuth, and in the *Journ.* Soc. of Chem. Ind., Feb. 15, 1908, H. W. Powell discussed the determination of small quantities of bismuth.

BORAX.

By Frederick W. Horton.

There was little or no change in the condition of the borax mining industry in the United States during 1909. As in previous years the output continued to come from California. The Pacific Coast Borax Company in Inyo county and the Sterling Borax Company at Lang in Los Angeles county were the principal producers. The output during the last two years has varied but little, mining being carried on to keep pace with the consumption, which has not increased to any notable extent, if at all. The accompanying table shows the quantity and value of the borax produced in California for a period of years.

PRODUCTION OF BORAX IN CALIFORNIA. (a)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1898........	8,300	$ 1,153,000	1902......	(b)17,202	$2,234,994	1906......	58,173	$ 1,182,410
1899........	20,357	1,139,882	1903......	34,430	(c) 661,400	1907......	53,412	1,200,913
1900........	25,837	1,013,251	1904......	45,647	(c) 698,810	1908......	22,200	1.117,000
1901........	7,221	982,380	1905......	46,334	1,019,158	1909......	16,629	1,163,960

(a) Reported by the California State Mining Bureau. (b) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (c) Spot value.

Industrial Conditions and Prices.—During 1909 the market for borax showed but slight improvement over that of the previous year. In January quotations on sacked borax rose ½c. to 4⅝c. per lb. and remained at this figure until December when there was a recession to 4⅜c. per lb. It is reported, however, that sales of large lots were made at 3¾@4c. per lb. Boric acid was steady at 7c. per lb. throughout the year.

Borax in California.

Outside of the operations of the Pacific Coast and Sterling Borax companies, no mining of any importance was carried on in 1909. Both these companies worked veins of colemanite, the former shipping the crude borax to its refinery at Bayonne, N. J., and the latter to its various refining plants at New Brighton, Penn., San Francisco, and Chicago. Most of the mineral mined contained 35 to 45 per cent. anhydrous boric acid and was shipped direct, but some lower grade mineral was calcined at the mines.

In 1909 the Borax Consolidated Company, composed of London people, completed a borax refining plant at Otis, a station on the Santa Fé railway, in San Bernardino county. The plant has a capacity of 150 tons of refined borax per day. The company has been developing a group of borax mines in the Otis section for several years and has opened up a large reserve. Hitherto it has been the practice to ship the borax to New Jersey for refining.

At the Lang mine of the Sterling Borax Company, two veins of colemanite, one 16 ft. wide and 1000 ft. long and the other, 30 ft. distant, 7 ft. wide and 500 ft. long, are being developed. In 1909 a branch railroad was built connecting this mine with the Southern Pacific system. The Borax Properties, Ltd., has a surface deposit at Otis, which is expected to become productive shortly. Several of the companies which formerly worked deposits in Ventura and San Bernardino counties have become a part of the Sterling Borax Company and their old mines have been abandoned. There is some talk of one or two claims at Griffin and Frazier, Ventura county, beginning operations again in the summer of 1910, but this is somewhat doubtful if prices of refined borax do not advance. With such an increase in price a number of claims once worked may again become producers, but until this happens their rehabilitation is not probable.

Borax in Foreign Countries.

Argentine Republic.—Extensive deposits of ulexite (hydrous borate of sodium and calcium) have long been known to exist in the Atacama desert. The borate occurs in beds having an average thickness of about three feet, and mineral containing from 30 to 40 per cent. boric anhydride is plentiful. Owing, however, to the difficulties of transportation and high freight rates, these deposits are, with one or two exceptions, either totally unexplored or now abandoned. At the *boratera,* or Tres Morros, north of the town of Morenno, in the State of Jujay, La Sociedad Belga de Borax is operating on a large scale. The borate mineral occurs in nodular form, and although the beds are situated in the midst of a salt deposit, the borate is contaminated with but little sodium chloride. An analysis of an average sample shows boric anhydride, 36.90 per cent.; sodium, 9.03; lime, 12.10; water, 33.20; sodium chloride, 5.08; sand and silicate of aluminum, 3.05; and ferric oxide, 1.15. The average thickness of the deposit is about 2½ ft. The borate nodules are dried in the air and then screened to separate adhering earth and sand. They are next conveyed in small wagons to the works, where they are calcined in rotating cylinders. The calcined mineral containing 50 per cent. boric anhydride is exported. At the *salar* of Caurchari, which is two days' journey north of Antuco, in the state of Atacama, the borate beds are being exploited on a small scale. The deposit is 6 ft. thick. Concentration is effected by washing, drying the washed product in the air, and then calcining.

Chile.—The most important borax deposits of Chile are situated at Ascotan and Chilcaya in the state of Antofagasta, near the Bolivian boundary line. The Borax Consolidated Company, Ltd., controls the deposits, having a monopoly from the Chilean government. The crude borax containing about 36 per cent. boric acid is air dried and then calcined in reverberatory ovens. The calcined product containing approximately 45 per cent. boric acid is sacked and shipped from the port of Antofagasta to Europe. In 1909 Chile produced 32,218 metric tons of borax valued at $1,646,342, as compared with 35,039 metric tons, valued at $1,790,495, in 1908.

Peru.—The principal borate deposits of Peru are those of the Laguna de Salinas, which is situated on the boundary line between the departments of Arequipa and Moquega. The borate occurs as ulexite near the surface of a sedimentary deposit filling the basin of the lagoon. An average section of the deposit in descending order is as follows: Superficial crust of sodium chloride and sodium sulphate; fine sand, 4 to 6 in.; quartz sand, 2 in. or more; sand with seams of borate, 8 to 20 in.; fine

SOME OF THE PRINCIPAL SUPPLIES OF BORAX PRODUCTS.
(In metric tons.)

Year.	Chile. (*a*)	Germany (*b*)	Italy.			United States. (*c*)	Total. (*d*)
			Borax Refined.	Boric Acid.			
				Crude.	Refined.		
1897....	3,154	198	990	2,704	260	7,257	14,563
1898....	7,028	230	702	2,650	166	7,529	18,305
1899....	14,951	183	709	2,674	129	18,466	37,112
1900....	13,177	232	858	2,491	283	23,437	40,478
1901....	11,457	184	544	2,558	347	6,550	21,640
1902....	14,327	196	....	2,763	....	15,512	32,798
1903....	16,879	159	....	2,583	....	31,232	50,853
1904....	16,733	135	569	2,624	314	41,407	61,782
1905....	19,612	183	(*e*)1,007	2,700	(*e*)749	42,036	64,531
1906....	28,996	161	1,062	2,561	562	52,774	86,116
1907 ...	28,374	114	881	2,305	466	48,444	80,584
1908....	35,039	128	(*e*)1,024	2,520	(*e*)429	20,140	57,827

(*a*) Prior to 1903, figures are for borate of lime exports. (*b*) Boracite. (*c*) Crude borax. (*d*) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (*e*) Obtained by treating a part of the crude boric acid reported for the same year.

sand, thin, sometimes absent; seam of borate of variable thickness, averaging 16 in., and attaining a maximum of $3\frac{1}{4}$ ft. The crude mineral containing about 30 per cent. of boric acid is extracted from excavations about $3\frac{1}{4}$ ft. wide and 10 ft. long and carried by a light railway to the drying ovens. After drying, the mineral, which may now contain as much as 52 per cent. boric acid, is sacked and taken by pack animals to Arequipa.

Bibliography of Borax in 1909.

The following articles contain valuable information relative to the borax industry:

Anonymous. "The Borate Fields of Chile." (*Chem. Trade Journ.*, Oct. 23, 1909; 2 pp.)

Keyes, Charles R. "Borax Deposits of the United States," with discussion by A. M. Strong. (*Trans.* A.I.M.E., 1909, pp. 867-903, and 1910 pp. 167-171.)

Keyes, Charles R. "American Borax Deposits." (*Eng. and Min. Journ.*, Oct. 23, 1909; 1½ pp.)

Wainewright, W. B. "Borate Deposits of California." (*Trans.* Manchester Geol. and Min. Soc., Jan., 1909; 8 pp.)

Wilson, E. B. "Boron." (*Mines and Minerals*, Oct., 1909; 2 pp.)

BROMINE.

Owing to depressed market conditions, the production of bromine in the United States during 1909 showed a slight decrease from that of the preceding year. The industry in the United States is confined to Michigan and those portions of Pennsylvania, Ohio and West Virginia lying along the Ohio river. Michigan is by far the most important producer; almost the entire production of that State in 1909 was contributed by the Dow Chemical Company, for which reason the statistics of Michigan cannot be itemized without disclosing confidential information. The Saginaw Salt Company ceased the production of bromine in 1909, and the St. Louis Chemical Company, of St. Louis, Mich., produced none. The output of West Virginia during 1909 was slightly smaller than in 1908, while that of Pennsylvania and Ohio recorded a notable decrease.

PRODUCTION OF BROMINE IN THE UNITED STATES.

(In pounds.)

Year	Michigan. (a)	Ohio and Penna.	West Virginia.	Total (a)	Metric Tons.	Value.	
						Total.	Per lb.
1897	147,256	241,939	97,954	487,149	221	$136,402	28c.
1898	141,232	226,858	118,888	486,978	220	136,354	28
1899	138,272	193,518	101,213	433,003	196	125,571	29
1900	210,400	196,774	114,270	521,444	237	140,790	27
1901	217,995	227,062	106,986	552,043	250	154,572	28
1902	226,452	194,086	93,375	513,913	233	128,742	25
1903	320,000	180,000	97,000	597,000	271	170,145	28½
1904	646,249	147,807	85,256	879,312	399	215,431	24½
1905	579,434	223,000	97,000	899,434	408	139,492	15½
1906	955,000	203,000	71,000	1,229,000	553	184,350	15
1907	(b)	(b)	(b)	1,062,000	482	138,060	13
1908	(b)	(b)	(b)	1,149,000	521	103,410	9
1909	(b)	(b)	(b)	1,100,000	500	110,000	10

(a) Includes the bromine equivalent of the bromides produced directly. (b) Not reported separately.

During 1909 the price of commercial bromine remained steady at 10c. per lb. at the place of production. Potassium bromide was quoted at New York at 18c. per lb. in January, after which the price rose to 20c. and remained there during the rest of the year. The advance was due to the withdrawal of the German producers from the American market, which took place at the end of 1908. So far as we can learn, no bromine or bromides were exported from the United States in 1909. The low price of bromine during 1909 caused some manufacturers to suspend production of bromine and turn their attention more particularly to the manufacture of calcium chloride. In Germany the Mansfeld Mining Company and the Heyden Chemical factory joined the convention of bromine manufacturers, strengthening that association to a considerable extent in its competition with the American producers.

An excellent article on the technology of the manufacture of bromine, by Oscar C. Diehl, will be found in Vol. XVII of The Mineral Industry.

CADMIUM.

The production of cadmium in the United States in 1909 was 5300 ℔., compared with 10,000 ℔. in 1908. The production in Upper Silesia was 80,300 ℔. in 1909, compared with 68,200 ℔. in 1908. In THE MINERAL INDUSTRY, Vol. XVII, it was stated that in 1908 there was also a production of cadmium in Great Britain, for which no statistics were available. No information respecting this production in 1909 has come to hand, but if there were any, the amount was probably small, and for all practical purposes the world's production in 1909 may be taken as 85,600 ℔., against 78,200 ℔. in 1908, and 85,550 ℔. in 1907.

The price for cadmium in the United States in 1909 ranged from 60 to 75c. per ℔. for lots of 200 ℔. and over. At the beginning of 1908 the price was $1.25, which later was reduced to 75c., the quotation at the year's end being 80c. In Upper Silesia at the beginning of 1909 the price for bars 99½ per cent. pure was 500 marks per 100 kg. Owing to the largely increased supply, the price continued to fall from month to month, until in the autumn the low level of 400 marks was reached. Toward the end of November a new and extraordinarily strong demand began, said to be for a new use for the metal, and large quantities of stock being taken out of the market, the price advanced, 550 marks being realized at the end of the year. At that time it was reported that the good demand continued, both in Germany and from abroad.

CARBORUNDUM.

The Carborundum Company, of Niagara Falls, N. Y., continues to be the only manufacturer of carborundum in the United States. The considerable increase in the production for 1909 was indicative of the better conditions existing in the metal and manufacturing trades, in which the demand for the abrasive largely originates. The manufacture of carborundum was begun experimentally in 1891 by Edwin Goodwin Acheson, and was organized as a business when 10 carats of the material was ordered by workers of precious stones at the rate of $860 per ℔. The progress that the industry has since made may be seen from the accompanying table:

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

Year.	Pounds.	Metric Tons.	Value.
1891	50		
1892	2,145	1	
1893	15,200	7	
1894	52,190	24	
1895	225,930	102	
1896	1,190,600	540	$365,612
1897	1,242,929	564	153,812
1898	1,594,152	724	151,444
1899	1,741,245	791	156,712
1900	2,401,000	1,089	168,070
1901	3,838,175	1,742	268,672
1902	3,741,500	1,698	261,905
1903	4,760,000	2,160	333,200
1904	7,060,380	3,203	494,227
1905	5,596,280	2,539	391,740
1906	6,225,280	2,824	435,770
1907	7,532,670	3,418	451,960
1908	4,907,170	2,226	294,430
1909	6,478,290	2,938	388,697

During 1909 the plant of the Carborundum Company was enlarged by the erection of a four-story building, which will be utilized for the installation of additional furnaces and will accommodate the mixing and wheel-molding departments of the company. No changes of importance were introduced in the method of manufacture. During a run which lasts 36 hours, each furnace consumes 2000 h.p. The voltage, starting at about 250, is lowered as the resistance decreases until it comes down to an average of about 185. The carborundum crystals are crushed under manganese steel rollers in a circular pan of similar material. The crushed product is then treated in a bath of sulphuric acid, to dissolve the minute particles of steel that have been cut from the rolls and pan. This method of treatment has been found more satisfactory than the removal of the steel by magnets. The carborundum, after washing to free it from acid, is screened into different grades and is then ready for manufacture. The technology and uses of carborundum are thoroughly reviewed by F. J. Tone in Vols. XV-XVII, inclusive, of The Mineral Industry.

CEMENT.

The production of portland cement in the United States in 1909 is estimated at a minimum of 61,300,000 bbl., which, valued at 85c. per bbl. at the mills, was worth $52,105,000. This is an increase of at least 20 per cent. over the production of 1908. The output of natural cement in 1909 was 1,500,000 bbl., valued at $675,000, an average value of 45c. per bbl. These figures show a slight decrease as compared with those for 1908, when the production was 1,686,000 barrels. The production of puzzolan cement showed a slight increase, about 160,646 bbl., valued at $99,453, having been produced in 1909, as compared with 151,451 bbl., valued at $95,468, in 1908. The increase in the output of portland cement, over 10,000,000 bbl., is the largest that has occurred since 1906, and doubtless reflects renewed activity in many lines of industry. The use of natural cement continues to decline, and slag cement likewise seems to have lost much of its earlier popularity.

PRODUCTION OF CEMENT IN THE UNITED STATES. (*a*)
(In barrels.)

Year	Portland.			Natural Hydraulic.			Puzzolan Cement.			Total.	
	Barrels.	Value.	Per bbl.	Barrels.	Value.	Per bbl.	Barrels.	Value.	Per bbl.	Barrels.	Value.
1898	3,584,586	$ 6,168,106	$1.72	8,168,106	$3,819,995	$0.47	157,662	$235,721	$1.50	11,903,326	$10,223,822
1899	5,805,620	10,441,431	1.80	9,686,447	5,058,500	0.52	244,757	360,800	1.47	15,736,824	15,786,789
1900	8,482,020	9,280,525	1.09	8,383,519	3,728,848	0.45	446,609	567,193	1.27	17,312,148	13,576,566
1901	12,711,225	12,532,360	0.98	7,084,823	3,056,278	0.43	272,689	198,151	0.73	20,068,737	15,860,731
1902	17,230,644	20,864,078	1.21	8,044,305	4,076,630	0.50	478,555	425,672	0.81	25,753,504	25,366,380
1903	22,342,973	27,713,319	1.19	7,030,271	3,675,520	0.50	525,896	542,502	1.03	29,899,140	31,931,341
1904	26,505,881	23,355,119	0.90	4,866,331	2,450,150	0.50	303,045	226,651	0.75	31,675,257	26,031,920
1905	35,246,812	33,245,867	0.94	4,473,049	2,413,052	0.54	382,447	272,614	0.71	40,102,308	35,931,533
1906	46,610,822	51,240,652	1.10	3,935,151	2,362,140	0.60	481,224	412,921	0.86	51,027,321	54,015,713
1907	48,785,390	53,992,551	1.10	2,887,700	1,467,302	0.51	557,252	443,998	0.79	52,230,342	55,903,851
1908	51,072,612	43,547,679	0.85	1,686,682	834,509	0.49	151,451	95,468	0.63	52,910,925	44,477,653
1909	61,300,000	52,105,000	0.85	1,500,000	675,000	0.45	160,646	99,453	0.62	62,960,646	52,879,453

(*a*) Statistics of production for 1900 and subsequent years are as reported by the U. S. Geological Survey, those for 1909 being subject to revision. The barrel of portland cement contains 380 lb. of the material; of natural cement, 265 lb.; of slag cement, 330 lb.

Cement Making in the United States.

Alabama.—Only one plant, that of the Standard company, at Leeds, Jefferson county, made portland cement in 1909; its output was 180,000 bbl. A small amount of slag cement was made in Birmingham.

Georgia.—Both natural and portland cement are made in Georgia. The only producer of the former during 1909 was the Southern States

Portland Cement Company, at Roekmart. The Piedmont Portland Cement Company eontinued the ereetion of its plant, and a new eompany, the Georgia Portland Cement and Slate Company, was organized. The materials used by the Southern States Portland Cement Company are the Chiekamauga limestones and the Roekmart shales. The

STATISTICS OF CEMENT IN THE UNITED STATES.

Year.	Production.		Imports.		Exports.		Consumption.	
	Barrels.	Value.	Barrels. (a)	Value.	Barrels.	Value.	Barrels.	Value.
1898..	11,903,326	$10,223,822	2,119,880	$2,624,228	55,969	$ 98,121	13,967,237	$12,749,929
1899..	15,736,824	15,860,731	2,219,246	2,858,286	116,079	213,457	17,839,991	18,505,560
1900..	17.312,148	13,576,566	2,512,300	3,330,445	147,305	289,186	19,677,143	16,617,825
1901..	20,068,737	15,786,789	994,624	1,305,692	303,380	752,057	20,759,981	16,340,424
1902..	25,735,504	25,366,380	2,100,513	2,582,281	367,521	575,268	27,486,496	27,373,393
1903..	29,899,140	31,931,341	2,439,948	3,027,111	312,163	466,140	32,026,925	34,492,312
1904..	31,675,257	26,031,020	1,101,361	1,383,044	816,640	1,158,572	31,959,978	26,256,392
1905..	40,102,308	35,931,533	891,134	1,102,041	1,060,054	1,428,489	39,933,308	35,605,085
1906..	51,027,321	54,015,713	2,321,803	2,950,268	600,386	964,373	52,748,738	56,001,608
1907..	52,230,342	55,903,851	2,006,228	2,637,424	900,550	1,450,841	53,336,020	57,090,434
1908..	52,910,925	44,477,653	839,247	1,189,560	847,747	1,260,684	52,902,425	44,406,529
1909..	62,960,646	52,879,453	431,785	642,397	1,057,342	1,423,846	62,335,089	52,098,004

(a) Barrels of 400 lb.

shales lie direetly on the limestones, so that both materials are quarried together. Natural cement is made by the Howard Hydraulic Cement Company, at Cement, Bartow county, the Georgia Cement and Lime Company, at Linwood, and by the Chickamauga Cement Company, at Rossville, Walker eounty. The limestone used by the first two mentioned companies is found near the top of the Conasauga formation, while that used by the last company is found in the Chiekamauga formation, and is exposed over a eonsiderable area.

Maryland.—The Tidewater Portland Cement Company in 1909 began building its plant at Union Bridge. A novel feature will be the manufaeture of a white portland cement from limestone, whieh contains barely a traee of iron, and white clay.

The raw materials at this point eonsist of white limestone, eontaining between 98 and 99 per eent. of caleium carbonate, and shale whieh lies direetly on the limestone. The plant is being designed and built by the Fuller Engineering Company, of Allentown, Penn. The kilns will be 8 ft. in diameter and 123 ft. long. The raw material will be dried by the waste heat of the kilns. There will also be an extensive elinker storage, thereby insuring a sound and uniform produet. White Portland eement will be manufactured in a separate unit. It is expeeted that by the spring of 1911 the eement plant will be in operation.

Nebraska (By E. H. Barbour.)—Large exposures of limestone and shale suited to the manufacture of portland eement oeeur in the southeastern corner of the State, in the Pennsylvania formation. In northern and northeastern Nebraska, along the Niobrara river, and especially in the vicinity of the town of Niobrara, may be found great bluffs of cretaceous chalk and shale, such as is used by the Yankton Cement Company across the Missouri river in South Dakota. The beds are advantageously located, with respect to shipping facilities by rail and river. Along the southern border of the State the same formation outcrops along the Republican river; and at Superior, where there are several competing railroad lines, the Nebraska Portland Cement Company has been incorporated. The cement possibilities are great in spite of the fact that native coal cannot be depended upon for manufacturing purposes.

New Jersey (By H. B. Kümmel.)—The mills of the Alpha Portland Cement Company, the Vulcanite Portland Cement Company, and the Edison Portland Cement Company were all in operation during 1909, but were shut down, or ran at only part capacity, for considerable portions of the year. The total production amounted to 4,044,623 bbl., as against 3,208,446 bbl. for 1908, a gain of 836,177 bbl. over the previous year. In every case the production was far short of the reported capacity, ranging from 52 to 68 per cent., with an average of 61 per cent. for the entire State.

The total selling value for 1909, in bulk at the mills, was $2,656,108, as against $2,420,868 for 1908, an increase of $235,240, or 9.7 per cent. The gain in amount of cement was 26 per cent., while in value it was less than 10 per cent. During 1908 the average selling price in bulk was 75c. per bbl., whereas in 1909 it was only 65.6 cents.

In the three plants reporting, the number of kilns in operation were as follows: Eighteen 60-ft. kilns, six 100-ft., eight 125-ft., and ten 150-ft. kilns. These figures show an increase in the number of 125-ft. kilns, a decrease in the 60-ft. kilns and a decrease in the total number, with an increase in the total capacity.

The above figures afford no encouragement for the promotion of new cement plants. On the contrary, they only emphasize what has been said before, that the present capacity of the mills of this State, at least, is far in excess of the present consumption and is more than able to take care of any probable increase in the near future. It may be well to note also that a large cement company in a neighboring State, which was widely boomed two or three years ago as a gilt-edged proposition, and whose securities were sold more or less extensively in New Jersey, passed into the hands of receivers before the plant was fairly in operation.

New York (By D. H. Newland.)—The cement industry of New York held its own during 1909, which, in the circumstances, was all that could have been expected. Though the market was undoubtedly a little broader than in the preceding year, the improvement did not suffice to bring about any decided rise in prices, which continued at nearly the same level as in the panic times of 1907. The period of depression was prolonged by the wide disparity between productive capacity and consumption. This condition seems to have been definitely relieved at last, and the outlook at the beginning of 1910 is more encouraging than it has been in the last two years. Local manufacturers have enjoyed some advantages in marketing their products through the large engineering developments in connection with the canal system, municipal water-supply plants, hydro-electric installations, etc., that have been under way in the State.

The combined production of portland and natural cements amounted to 2,610,383 bbl., valued at $2,122,802, or 100,000 bbl. more than in 1908. The increase came from the portland cement plants, which contributed approximately 2,061,019 bbl., valued at $1,761,297 to the total. The natural cement industry, once so important, has been reduced to small proportions and is now centered almost entirely in the Rosendale district. The output of natural cement in 1909 was 549,364 bbl., valued at $361,605.

Of the new projects in the Hudson River region mentioned in the review for last year, the plant of the New York-New England Cement and Lime Company, is the only one which has approached completion so nearly as to make it a probable factor in the trade during the current season. This enterprise is controlled by interests connected with the Atlas Portland Cement Company, of Pennsylvania. It is expected to begin operations in 1910. The capacity has been placed at 5000 bbl. per day. A moderate gain in the portland cement production of the State may be anticipated for the present year, and under favorable market conditions, a decided increase in 1911.

Utah.—The cement industry in Utah is growing. The principal outputs were at Devil's Slide on the Southern Pacific east of Ogden and from Parley's cañon near Salt Lake City. At Devil's Slide is a large and modern plant. The largest Salt Lake plant was closed to undergo repairs and extensions. Construction was begun on a new plant near Brigham City in Box Elder county.

The Utah Portland Cement Company has for many years done a flourishing business at its works in Salt Lake City. The cement rock is brought in from Parley's cañon, Salt Lake county. The Union Portland

Cement Company, of Ogden, is now operating a 2000-bbl. plant near Croydon, Weber cañon, where it secures its calcareous shales and limestones for a very high-grade cement. The plant is modern in every detail, and the Red Devil brand cement is being widely distributed.

Cement Making in Foreign Countries.

Canada.—Complete statistics have been received from all but two cement manufacturers in 1909. These, however, will not increase the totals by more than 2 or 3 per cent. Subject to this correction, the total quantity of cement made during the year was 4,089,191 bbl., as compared with 3,495,961 bbl. in 1908, an increase of 593,230 bbl., or 17 per cent. The total quantity of Canadian portland cement sold during the year was 4,010,180 bbl., as compared with 2,665,289 in 1908, an increase of 1,344,891 bbl., or 60 per cent. The total consumption of portland cement in 1909, including Canadian and imported cement, was 4,152,374 bbl., as compared with 3,134,338 in 1908, an increase of 1,018,036 bbl., or 32 per cent.

The average price per barrel at the works in 1909 was $1.31 as compared with $1.39 in 1908. The imports of portland cement into Canada during 1909 were 142,194 bbl. The duty is 12½c. per 100 lb. As there is very little cement exported from Canada, the consumption is practically represented by the Canadian sales together with the imports. An estimate of the Canadian consumption of portland cement for the past five years shows that it increased from 2,285,240 bbl. in 1905 to 4,152,374 in 1909. In the five years the Canadian production increased from 1,346,548 to 4,010,180 bbl., while there was a decrease from 918,701 to 142,194 bbl. in the imports.

STATISTICS OF CANADIAN CEMENT.

Year.	Natural Cement.			Portland Cement.			Imports.
	Bbl.	Value.	Per Bbl.	Bbl.	Value.	Per Bbl.	Bbl.
1897	85,450	65,893	.771	119,763	209,380	1.748	....
1898	87,125	73,412	.842	163,084	324,168	1.987	....
1899	141'387	119,308	.843	255,366	513,983	2.012	....
1900	125,428	99,994	.797	292,124	562,916	1.927	....
1901	133,328	94,415	.708	317,066	565,615	1.783	555,900
1902	127,931	98,932	.773	594,594	1,028,618	1.729	544,954
1903	92,252	74,655	.809	627,741	1,150,592	1.834	773,678
1904	56,814	50,247	.884	910,358	1,287,992	1.414	784,630
1905	14,184	10,274	.724	1,346,548	1,913,740	1.421	918,701
1906	8,610	6,052	.703	2,119,764	3,164,807	1.493	665,845
1907	5,775	4,043	.704	2,463,093	3.777,328	1,555	672,630
1908	1,044	815	.781	2,665,289	3,709,139	1.390	469,049
1909	....	....	....	4,010,180	5,266,008	1.310	142,194

The 23 plants in operation in 1908 were distributed as follows: One each in Nova Scotia, British Columbia and Manitoba, the latter manufacturing a natural portland, two in Alberta, three in Quebec and 15 in Ontario. Of the 23 operating plants, 12 use marl and clay, 10 use limestone and clay, and one blast-furnace slag.

Chile.—A native company capitalized at $500,000 has begun the manufacture of cement in Chile, an extensive plant having been put in operation at Calera, a few miles from Valparaiso, where large deposits of the requisite material are found. The capacity of the plant is about 100,000 barrels per annum, which is expected to supply the normal demand of the country. About 200,000 bbl. of cement are imported annually.

China (By T. T. Read.)—Cement is being made by but one company in China, the Chee Hsin Cement Company, at Tongshan, in Chili province. This was formerly an auxilliary company of the Chinese Engineering and Mining Company, but is now independent. Two plants are in use. an old one in which the cement is burned in kilns, and a new plant with Smidth machinery of the latest design. The production for 1908 was 200,000 barrels.

CHROMIUM AND CHROME ORE.

By Frederick W. Horton.

The only deposits of chromic iron which were mined in the United States in 1909 were those on Shotgun creek in the western part of Shasta county, California. Here the ore occurs in lenticular beds and carries about 44 per cent. chromic oxide. Several hundred deposits of chromic iron are known in the coast range of California, but most of the ore is of too low grade to meet the requirements of the market. Chrome ore has been mined in Alameda, Del Norte, Fresno, Placer, San Luis Obispo, Sacramento, Sonoma and Tehama counties, but at present none of these deposits is being worked.

As may be noted from the accompanying table, domestic production is insignificant as compared with total consumption.

STATISTICS OF CHROME ORE IN THE UNITED STATES.
(In tons of 2240 lb.)

Year.	Production (a)			Imports.			Consumption.	
	Long Tons.	Value.	Value per Ton.	Long Tons.	Value.	Value per Ton.	Long Tons.	Value
1897	*Nil.*	......	......	11,566	$186,313	$16.11	11,566	$186,313
1898	*Nil.*	......	......	16,304	272,234	16.70	16,304	272,234
1899	*Nil.*	......	......	15,793	284,825	18.03	15,793	284,825
1900	140	$1,400	$10.00	17,542	305,001	17.39	17,682	306,401
1901	130	1,950	15.00	20,112	363,108	18.05	20,242	365,058
1902	315	4,725	15.00	39,570	582,597	14.73	39,885	587,322
1903	150	2,250	15.00	22,931	302,025	13.13	23,081	304,275
1904	123	1,845	15.00	24,227	348,527	14.38	24,350	350,372
1905	40	600	15.00	54,434	725,301	13.32	54,874	725,901
1906	317	2,859	9.00	43,441	557,594	12.84	43,758	560,453
1907	335	5,620	20.00	41,999	491,925	11.71	42,333	498,605
1908	280	5,600	20.00	27,876	345,960	12.40	28,156	351,560
1909	205	4,100	20.00	39,624	460,758	11.63	39,829	464,858

(a) As reported by the California State Mining Bureau except for 1907 to 1909 inclusive, for which years the statistics are compiled from our own reports.

The entire production of chrome iron ore in California is utilized for lining furnaces at copper smelteries within the State. Foreign ore coming chiefly from Asiatic Turkey and New Caledonia finds its principal market in the eastern States. The Mutual Chemical Company of America, with plants at Baltimore and Boston, is the chief consumer of chrome ore for the manufacture of chemicals, and controls the largest part of the output of chrome salts in the United States. The Harbison-Walker Refractories Company of Pittsburg is the principal manufacturer of chrome brick, and the Chrome Steel Works of Chrome, N. J., is the leading producer of ferro-chrome alloys.

Prices.—In May, 1909, there was a sharp decline in the price of imported chrome ore. During the first four months of the year New Caledonian ore, 50 per cent., ex-ship, New York, brought $17.50@20 per long ton, but on the break in price fell to $14@16, remaining steady at these figures for the remainder of the year. The average price for 1909 was $16.24 per long ton, as compared with $17.50 in 1908. Chrome bricks were steady at $175 per M., f.o.b. Pittsburg.

Chrome Ore in Foreign Countries.

Africa.—In 1909 shipments of chrome iron ore from the Beira in Portuguese East Africa amounted to 22,871 tons. The ore was mined in Rhodesia and sent by rail from Selukwe to Beira for shipment. The greater part of the ore comes to the United States, but some has been shipped to France, Holland and Belgium, as well as to Italian and British ports. Imports of chrome ore into the United States from Portuguese East Africa in 1909 were 11,470 tons as against 4225 tons in 1908.

Austria-Hungary.—Small quantities of chrome iron ore are mined in Austria-Hungary. In 1908 exports of this ore amounted to 1435 metric tons of which 1118 tons were shipped to Germany.

Canada.—In 1908 total shipments of chromite from mines in Canada were 7225 short tons, valued at $82,008, and consisted of 3472 tons of concentrates valued at $45,300 and 3753 tons of crude ore valued at $36,708. Canadian chromite finds its chief market in the United States, although a few carloads are shipped annually to Canadian points. In 1908 exports to the United States were 6505 short tons valued at $69,009. All the productive mines are in the Thetford-Black Lake area of the eastern townships of Quebec, more especially in the township of Coleraine. The chromite is found in serpentine, as a rule in irregular masses and pockets which have dimensions of from a few feet up to 50 or 75 ft., or disseminated throughout the rock in a fine state of division. The mining of chromite will consequently always be attended with much uncertainty on account of the pockety nature of the deposits. Three companies are in the field, the Black Lake Consolidated at Black Lake, the Canadian Chrome Company near Thetford, and the American Chrome Company with mines in the vicinity of Black Lake. These companies are operating 75 stamps with a total approximate capacity of 150 tons of rock per day and employ about 150 men during the summer season. Ferro-chrome is manufactured from domestic ore at Buckingham, Quebec, by the Electric Reduction Company, and shipments have also been made to the steel furnaces at Sydney and Sault Ste. Marie.

India.—The entire chromite production of India comes from the two States of Mysore and Baluchistan. The production in 1908 amounted to 4745 long tons, valued at $30,841, as compared with 18,303 long tons valued at $118,750 in 1907. The large decrease in output was due to the production of 11,197 tons in Mysore in 1907 (the first year of production in that State out of which only 856 ons were sold, leaving a large stock to be carried over to 1908.

New Caledonia.—This country is the chief source of the world's supply of chrome ore. Exports for 1909 were 32,136 metric tons, or 14,344 tons less than in 1908. The price of the mineral has reached a very low figure and is quoted at $5.35 per ton for 50-per cent. ore in bulk at the mines, or $8.35 per ton f.o.b. Noumea in sacks. The stock of chrome ore existing in the colony December 31, 1909, was approximately 21,000 metric tons. The output of the year was entirely from one mine, and on account of the large stock on hand this mine has reduced its output to about 3000 tons per month.

Newfoundland.—Several large deposits of chrome iron ore are known to exist in Newfoundland. They are chiefly situated at a distance from the sea-board and only one attempt to mine the ore has been made near Port-au-Port bay on the west coast. From this deposit about 6000 tons of high-grade ore were mined and exported between the years of 1895 and 1899. Since then no mining has been carried on, but several extensive deposits have been discovered inland from the same bay and on the head waters on the Bay d'Est and Gander river.

Russia.—The principal chrome iron deposits in Russia are in the Urals. There are about 50 mines in this district and their combined output in 1907 was 1,559,148 poods (25,528 metric tons). The 1908 production showed a marked decrease, amounting to only 556,637 poods (9278 metric tons). In 1909 the average price of ore at Ekaterinburg was 20 to 25 copecks per pood ($5.72 to $7.15 per short ton).

Turkey.—Although both European and Asiatic Turkey are producers of importance, no complete statistics of the chrome iron output of the country are available. During the years 1903 to 1907 inclusive, exports of chrome iron from Turkey to the United States aggregated 28,482 long tons and to Great Britain, 91,800 long tons. During 1908 and 1909 there was a large decrease in the amount shipped. For example, in 1907, 4900 long tons of chrome ore were exported from Salonica, and in

1908 but 2100 tons. The decrease in production has been directly due to the steady decline in the price of the ore.

THE PRINCIPAL SUPPLIES OF CHROME ORE. (*a*)
(In metric tons.)

	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
Bosnia........	200	100	505	270	147	279	186	320	164	(*c*)	(*c*)
Canada.......	1,824	2,119	1,156	817	3,184	5,512	7,781	7,936	6,528	6,554	(*b*)1,627
Greece........	4,386	5,600	4,580	11,680	8,478	15,430	8,900	11,530	11,730	(*c*)	(*c*)
India.........	.....	.....	.....	.....	260	3,654	2,751	4,445	18,597	4,821	....
New Caledonia (*b*).........	12,480	10,474	17,451	10,281	21,437	42,197	51,374	57,367	25,371	46,890	32,136
New South Wales.......	5,327	3,338	2,523	454	1,982	403	53	15	30	*Nil.*	*Nil.*
Russia........	19,146	18,233	22,169	19,655	16,421	26,575	27,051	16,969	25,528	9,278	(*c*)
United States.	*Nil.*	142	132	320	152	125	40	322	339	284	208

(*a*) From the official reports of the respective countries. No complete statistics are available for Turkey or Africa. (*b*) Exports. (*c*) Statistics not yet available.

Bibliography of Chromium and Chrome Ore in 1909.

Anonymous. "The Whiteness and Non-tarnishing Properties of Chromium." (*Brass World*, March, 1909; ½ p.)

Anonymous. "Metallic Chromium and Its Properties." (*Brass World*, May, 1909; 1¼ pp.)

Cirkel Fritz. "Report of the Chrome Iron Ore Deposits in the Eastern Townships of the Province of Quebec." (Dept. of Mines of Canada, Ottawa, 1909.)

Jovitschitsch, M. Z. "A New Chromium Mineral in Servia." (*Monatsch. Chem.*, 1909; 7 pp.)

Muller, J. A. "Determination of Chromium in Chrome Iron Ore." (*Bull.* Soc. Chim., 1909; 3 pp.)

COAL AND COKE.

By Floyd W. Parsons.

The production of coal in the United States in 1909 was greater than in 1908, but did not reach the record total of the banner year, 1907. There was an increase of about 6½ per cent. in the production of bituminous coal; the anthracite production showed a decrease of about 3½ per cent. The first six months of the year were particularly dull, and the entire coal trade was enshrouded in an atmosphere of gloom. The

PRODUCTION OF COAL IN THE UNITED STATES.

(In tons of 2000 lb.)

Bituminous.	1908.			1909.		
	Short Tons.	Value at Mines.		Short Tons.	Value at Mines.	
		Total.	Per Ton.		Total.	Per Ton.
Alabama	11,523,299	$14,404,124	$1.25	12,872,619	$16,219,500	$1.26
Arkansas	1,866,565	2,893,176	1.55	(b) 1,940,000	3,104,000	1.60
California and Idaho	21,760	66,368	3.05	18,540	68,598	3.70
Colorado	9,703,567	13,099,815	1.35	10,736,459	14,708,949	1.37
Georgia	301,640	392,132	1.30	285,700	377,124	1.32
Illinois	49,272,452	50,257,901	1.02	(c) 49,163,710	50,638,621	1.03
Indiana	10,987,419	11,317,041	1.03	13 692,089	17,115,111	1.25
Iowa	7,149,517	11,439,227	1.60	7,166,253	11,680,992	1.63
Kansas	5,960,417	8,940,625	1.50	6,107,040	9,160,560	1.50
Kentucky	9,805,777	10,394,124	1.06	10,296,145	11,016,875	1.07
Maryland	4,377,094	5,116,378	1.20	4,524,112	5,609,899	1.24
Michigan	1,839,927	2,943,883	1.60	1,758,020	2,953,474	1.68
Missouri	3,400,644	5,747,088	1.69	3,787,431	6,438,632	1.70
Montana	1,979,417	3,561,921	1.85	2,541,679	4,829,190	1.90
New Mexico	2,772,586	3,881,620	1.40	3,010,000	4,515,000	1.50
North Dakota	317,840	556,220	1.75	354,305	627,120	1.77
Ohio	26,270,639	28,634,996	1.09	27,756,192	30,531,811	1.10
Oklahoma	3,633,108	7,447,871	2.05	4,192,400	9,013,660	2.15
Oregon	(a)86,259	236,021	2.74	91,400	251,350	2.75
Pennsylvania	118,309,680	130,140,648	1.10	136,205,695	149,826,264	1.10
Tennessee	6,082,851	6,961,393	1.14	7,090,420	8 153,983	1.15
Utah	1,786,204	2,911,513	1.63	2,322,209	3,947,755	1.70
Texas	1 280,490	2,048,784	1.60	1,859,259	3,307,051	1.79
Virginia	4,224,821	3,881,448	0.92	4,310,360	4,094,652	0.95
Washington	2,977,490	6,054,002	2.03	3,261,227	6,652,903	2.04
West Virginia	(c) 44,370,261	42.151,748	0.95	46,697,017	44,362,166	0.95
Wyoming	6,100,000	10,370,000	1.70	5,020,740	8,635,673	1.72
Alaska and Nevada	10,240	39,936	3.90	(b) 16,000	62,400	3.90
Total Bituminous	326,411,903	$375,890,003	$1.15	367,076,821	$427,903,323	$1.16
Anthracite.						
Colorado	69,440	$187,488	$2.70	72,100	$198,275	$2.75
New Mexico	(b) 20,000	60,000	3.00	(b) 14,000	42,000	3.00
Pennsylvania	80,240,138	158,875,473	1.98	77,040,880	152,540,942	1.98
Total Anthracite	80,329,578	$159,122,961	$1.98	77,126,980	$152,781,217	$1.98
Total coal { Short tons	406,741,481	535,012,964	1.31	444,203,801	580,684,540	1.31
Total coal { Metric tons	369,895,861	....	1.44	402,981,688	....	1.44

(a) As reported by the U. S. Geological Survey. (b) Estimated. (c) For fiscal year ending June 30.

PRODUCTION OF COKE IN THE UNITED STATES.
(In tons of 2000 lb.)

	1908.			1909.		
	Short Tons.	Value. Total.	Value. Per Ton.	Short Tons.	Value. Total.	Value. Per Ton.
Alabama	2,336,602	$7,056,538	$3.02	2,521,000	7,689,050	$3.05
Colorado	854,662	2,606,719	3.05	1,091,882	3,384,834	3.10
Georgia and North Carolina	41,980	146,930	3.50	(a) 50,000	175,000	3.50
Illinois	310,540	1,335,322	4.30	425,970	1,882,787	4.42
Kansas	10,000	37,000	3.70	(a) 12,000	43,200	3.60
Kentucky	54,515	122,659	2.25	38,849	87,410	2.25
Missouri	5,000	15,500	3.10	(a) 5,000	15,750	3.15
Montana	29,482	176,892	6.00	42,960	257,760	6.00
New Mexico	353,240	1,095,044	3.10	430,000	1,290,000	3.00
Ohio	240,000	672,000	2.80	250,000	725,000	2.90
Oklahoma	24,580	101,270	4.12	38,620	164,204	4.20
Pennsylvania	12,287,828	23,961,264	1.95	23,098,483	46,196,966	2.00
Tennessee	250,491	688,850	2.75	255,900	708,846	2.77
Utah	321,200	995,720	3.10	346,510	1,081,111	3.12
Virginia	1,219,927	2,781,433	2.28	1,294,942	2,978,366	2.30
Washington	37,381	205,595	5.50	42,335	241,309	5.70
West Virginia	(c) 2,978,203	6,313,917	2.12	3,125,451	6,688,465	2.14
Other States (b)	1,994,218	7,578,028	3.80	2,007,000	8,028,000	4.00
Total	23,028,649	$55,890,681	$2.43	35,076,902	$81,638,058	$2.33

(a) Estimated. (b) Includes output of by-product coke for Massachusetts, Maryland, Minnesota, New York, Michigan, Wisconsin. (c) Fiscal year ending June 30.

coke trade began to pick up immediately after the activity in the iron and steel industry commenced. The larger anthracite production in 1908 was caused by the desire on the part of hard coal operators to store fuel previous to the meeting of the wage-agreement committee, April 1. There was considerable apprehension at the time that a general strike of the miners might result. This increase in the production of anthracite continued to the latter part of 1908, and during the first three months of 1909. When labor troubles did not materialize, production was curtailed in order that stock might be worked off. The wage scale which was renewed in April, 1909, was practically a continuation of the same agreement that had been in force since the settlement of the big coal strike by the Anthracite Commission in 1903. The agreement is for a period of three years.

The close of 1909 showed great activity in all branches of the coal trade. The weather during the last month of the year was sufficiently cold to stimulate the domestic trade, while the demand for steam coals continued on an increased scale. Prices did not greatly increase, but the mines were able to work better time and the increased output was well taken up. The stagnation that existed in the coke industry during the first half of the year was entirely dispelled and this branch of the trade experienced an old-fashioned boom.

Coke prices were above $3 at the ovens, which prosperous condi-

IMPORTS OF COAL AND COKE INTO THE UNITED STATES. (a)
(In tons of 2240 lb.)

	1905	1906	1907	1908	1909.
Canada	1,331,292	1,427,731	1,398,194	1,107,737	1,043,419
Great Britain	94,600	106,771	42,830	36,989	17,225
Australia	184,426	191,758	552,918	327,441	182,271
Japan	41,956	11,996	123,720	31,792	14,344
Other countries	569	6,251	8,356	340	5,079
Total coal	1,652,843	1,744,507	2,126,018	1,504,299	1,262,338
Coke	181,376	128,461	132,355	129,591	170,671
Total	1,834,219	1,872,968	2,258,373	1,633,890	1,433,009

(a) Of the coal imported in 1909, there were 4709 tons classed as anthracite. Nearly all the imports were for the Pacific coast. The features of 1909 are found in the large falling off of imports from Australia and Japan. The unusual increase in the receipts of Australian and Japanese coal in 1907 was due to the expectation of a fuel famine in the West. The coke received is from British Columbia with the exception of a few thousand tons from Germany.

EXPORTS FROM THE UNITED STATES. (a)
(In tons of 2240 lb.)

	1905	1906	1907	1908	1909
Anthracite	2,229,983	2,216,969	2,698,072	2,752,358	2,842,714
Bituminous	6,959,265	7,704,850	10,448,676	9,100,819	9,693,843
Total coal	9,189,248	9,921,819	13,146,748	11,853,177	12,536,557
Coke	599,054	765,190	874,689	622,228	895,461
Total	9,788,302	10,687,009	14,021,437	12,475,405	13,432.018

(a) These figures do not include coal bunkered, or sold to steamships engaged in foreign trade.

tion caused the opening of many plants and ovens that had been temporarily abandoned. It was the purpose of a number of large operators to bring about a consolidation of all the coke-producing companies with the exception of those plants controlled by the Steel Corporation. For some unknown reason, this combination fell through. The price at which most of the independent operators valued their holding was about $5000 per acre.

The greatest gain in the coal and coke trade during 1909 was made in the Connellsville coking region. This increased activity in coke manufacture, as before stated, was caused by the rapid recovery in the iron trade in 1909. The production of coke in 1908 fell off nearly 50 per cent., while the output in 1909 returned well toward the high record established in 1907. In the latter part of 1909, the coking industry was greatly handicapped by a lack of labor and a scarcity of water. Shipments were also checked by a scarcity of railroad cars. This scarcity of labor and cars was felt in practically all of the eastern coal districts during the latter part of the year.

Perhaps the most noteworthy feature of the coal industry of the United States in 1909 was the absence of labor troubles. What few strikes occurred were of a local nature. The year was also exceptional

DESTINATION OF EXPORTS. (a)
(In tons of 2240 lb.)

	1905	1906	1907	1908	1909
Canada	6,964,630	7,533,346	9,843,315	9,252,943	9,782.574
Mexico	927,170	1,084,319	1,066,502	694,099	614,310
Cuba	564,385	689,833	804,310	690,867	723,594
Other West Indies	300,776	319,839	474,382	374,699	378,184
Europe	101,277	81,734	220,479	234,581	255,109
Other countries	331,010	212,748	737,760	605,988	782,786
Total	9,189,248	9,921,819	13,146,748	11,853,177	12,536,557

(a) The European exports in 1909 were chiefly to Italy, that country receiving 156,920 tons. Other countries are chiefly the South American republics. The Canadian shipments were 75.9 per cent. of the total in 1906; 74.9 in 1907, 78 per cent. in 1908, and 78 per cent. in 1909.

COAL PRODUCTION IN THE CHIEF COUNTRIES OF THE WORLD.
(In metric tons.)

Countries.	1904	1905	1906	1907	1908	1909
Asia:						
China	....	....	....	10,450,000	11,970,000	12,840,000
India	7,682,319	7,921,000	9,783,250	11,147,339	12,865,408	12,961,000
Japan	11,600,000	11,895,000	12,500,000	13,716,488	13,942,000	14,019,626
Australasia:						
New South Wales	6,116,126	6,035,250	7,748,384	7,850,000	7,992,300	8,050,000
New Zealand	1,562,443	1,415,000	1,600,000	1,831,009	1,904,276	1,741,200
Other Australia	769,723	805,000	870,000	900,000	870,000	(e) 900,000
Europe:						
Austria Hungary (c)	40,334,681	40,725,000	37,612,000	40,112,530	40,760,870	39,842,749
Belgium	23,380,025	21,844,200	23,610,740	23,705,190	23,678,150	23,561,125
France	34,502,289	36,048,264	34,313,645	36,753,627	37,622,556	37,971,858
Germany (c)	169,448,272	173,663,774	193,533,259	205,542,688	215,071,345	217,322,270
Italy	359,456	307,500	300,000	453,137	421,906	395,600
Russia	19,318,000	17,120,000	16,990,000	21,207,500	22,943,794	24,083,000
Spain (c)	3,123,540	3,199,911	3,284,576	3,250,000	3,871,480	3,520,000
Sweden	320,984	331,500	265,000	305,000	300,000	250,000
United Kingdom	236,147,125	239,888,928	251,050,809	267,828,276	261,506,379	263,774,822
North America:						
Canada—						
Western	2,619,816	3,183,909	3,717,816	4,780,301	4,304,600	4,245,856
Eastern	4,194,939	4,775,802	6,196,360	5,730,660	6,599,866	5,200,777
Mexico	....	....	....	....	....	919,338
United States	318,275,920	351,120,625	375,397,204	435,483,938	369,895,861	402,981,688
South Africa (a)	3,015,000	3,218,500	(e) 3,900,000	3,945,043	4,621,988	4,940,192
Other countries (e)	4,250,000	4,550,000	5,500,000	3,475,780	4,106,000	(e) 5,000,000
Totals	867,020,658	928,049,163	988,173,043	1,098,468,506	1,045,248,779	1 084,521,101

(a) Transvaal, Natal and Cape of Good Hope. (c) Includes lignite. (e) Estimated.

so far as accidents were concerned. In the Eastern States the mines were unusually free from serious explosions, the only important accidents of this character being the explosion at Wehrum, Penn., where 21 men were killed, and the disaster at the Lick Branch colliery in West Virginia, where 65 miners perished.

The year 1909, however, preserved the record of former years by showing at least one horror. This accident came in the form of a mine fire at the St. Paul mine, Cherry, Ill. It is a mistake to designate the St. Paul disaster as a mine explosion. There is little satisfaction in casting reflections or criticizing the management of mines where such accidents take place; however, it seldom occurs that such disasters happen without a sufficient cause, which is generally negligence or incompetency on the part of mine officials. The St. Paul mine was not properly equipped to combat successfully a serious mine fire, and as a consequence, nearly 400 lives were sacrificed. The main criticisms with reference to the Cherry disaster were that fire drills had not been practised, and that the shaft and the bottom near the shaft, and about the mine stable were far from being fire-proof. The accident impressed mining men with the importance of constructing fire-proof shafts and landings. The fatality also drew attention to the rapidity with which mine timbers covered with dry coal dust will flame and burn.

One other important question brought up by the St. Paul mine fire was the problem of providing safety chambers underground in coal mines. The dangers from mine fires are as great as those from explosions of gas and dust; this latest accident, therefore, has caused strong arguments to be advanced favoring the installation of safety chambers underground.

The greatest commercial problem confronting coal men is the question of establishing a proper selling price for their product. Our coal areas are so great and so widely distributed, that every year brings forth a new list of producing mines. The result is that few mines are working at more than 75 per cent. capacity; in such important coal-producing States as Illinois, the shipping mines of the State operated on an average less than 200 days during 1909. It is easy to see, therefore, that any increased demand for coal is met, not by a betterment in the price of the product, but generaly by an increase in production. In some instances the demands of labor have been excessive, so much so that one mine in Pennsylvania recently closed down and is filling its contracts by purchasing coal from other producers, rather than to operate on what is claimed would be an unprofitable basis.

In conclusion, it is safe to say that the great problem confronting the coal industry at the close of 1909 was, how to restrict production so that the present destructive competition will be eliminated and the entire industry placed on a safe and profitable footing. Such a step would be in the interests of the safety of our miners and the conservation of our coal resources, rather than in netting a higher money return to coal owners. Under present conditions, it is impossible for coal operators to adopt necessary precautions and at the same time mine coal profitably. Those mine owners who desire to advance the industry to a high plane and thus preserve their mines and the lives of their employees, are prevented from carrying out any such purpose by the keen competition of other operators who are less careful and whose sole aim is the production of coal at the lowest possible cost.

Review of Coal Mining by States.

Alabama.—(By Henry M. Payne.)—There is no coalfield in the United States which presents a more interesting field for the student of mining than the State of Alabama. Coal mining is carried on in twelve counties of the State, and in seven of these twelve, coke ovens are also operated. For the last four years the annual output of coal in Alabama has ranged from 11,000,000 to 15,000,000 tons, and the production of coke has been approximately 3,000,000 tons per year. Jefferson county leads all other counties in the number of operations (81 out of 215); coke ovens in operation (7496 out of 9823); total output (50 per cent. of whole); men employed (9039 out of 18,783); and has 29 out of the 58 gaseous mines in the State. Of the total 215 operations in the State, only nine have shafts, while 96 have drifts and 110 have slopes.

On account of the great difference in the thickness and pitch of the seams, the price paid for mining varies greatly, the minimum paid being 35c. per ton, and the maximum $1.10. The thinnest seam operated is the Montevallo seam, at Straven, which in some places is only 1 ft. 8 in. thick; the thickest seams are the Blocton No. 1, at Blocton, and the Mary Lee, at Porter, which are about 10 ft. thick. The average number of days worked in the whole State in 1909 was 200. The mines in Marion county led the list with an average of 248 days, while Blout county only averaged 144 days. The State as a whole is not organized, and some of the mines use convict labor, the principal advantage from this policy being a continuous output, rather than any reduction in the cost of production. Because of the coking of about one-third of the total output of the State, in many districts the coal is loaded on a mine-run basis; but in all the other districts, careful attention is paid to the production of lump coal through improved methods of mining and the avoidance of the shattering effects of explosives.

A serious change in sentiment has recently taken place in Alabama, and the majority of operators are urging the abolition of "shooting on the solid," and the use of black powder. On the other hand, there is a movement toward the introduction of undercutting machines, permissible explosives in connection with electric shot-firing devices, and also of the hydraulic mining cartridge with which several mines have been recently equipped. The late Mulga and Palos explosions have emphasized the value of such rescue equipment as the hospital car of the Tennessee Coal, Iron and Railroad Company, and the Draeger oxygen apparatus, with which nearly all the prominent companies are equipped. At all the larger mines, a first-aid corps is maintained, and in addition to the regular mine inspection by the State, a company inspector is usually employed. The reports of the inspectors and experts at the Mulga mine indicate the absolute necessity for continuous examination of all working places, a more extended use of the safety lamp, and the constant removal of all dust as fast as it accumulates in any mine where gas has ever been discovered, or where the location is such that it may be expected. The greatest damage to this mine was at the foot of the main shaft, and fortunately the escape shaft was so slightly injured as to be almost immediately available.

The power plants and general equipment of all the mines in the State are above the average, and the local conditions are such that almost every method of mining, timbering, haulage and ventilation may be seen in practical use. One of the longest slopes in the State, and worthy of special mention, is at the Blocton mine of the Tennessee Coal, Iron and Railroad Company. This haulway is perfect in alinement and grade for its entire length, and is a model of entry timbering and roadway maintenance. About one-fourth of all the coal produced in Alabama is washed at the mines. Approximately one-fifth of all the coal produced is machine-mined. Three-fourths of all the machines used are of the pick or puncher type.

Arkansas. (By James Douglas.)—There were 65 mines in operation in the State of Arkansas. Of this number, 34 were worked by shafts, 25 by slopes, and 6 by drifts. About 4516 men were employed in the mines in 1909. There are six coal-producing counties in the State, viz: Johnson, Pope, Logan, Sebastian, Scott and Franklin. They are situated in the northwestern part of the State. The counties producing the most coal are Johnson, Franklin and Sebastian. There are 12 slopes, nine shafts and one drift in Sebastian county; three slopes in Scott county; seven shafts and one slope in Johnson county; three shafts in Franklin county; three slopes in Pope county; four slopes and one shaft in Logan county. The mines in Sebastian county are owned by the Bolen-Darnell Coal Company, Central Coal and Coke Company, Woodson Coal Company, Smokeless Fuel Company, Western Coal and Mining Company, Sebastian Smokeless Coal Company, Smokeless Coal Company, Pig Coal Company, Patterson Coal Company, Bach-Denmen Coal Company, Conrady Coal Company, Greenwood Coal and Lumber Company, Fidelity Fuel Company, Hoffman Coal Company, Finey Coal Company, Mammoth Vein Coal Company and Quillin Coal Company. The mines in Scott county are owned by the Harper Coal Company and the Bates Coal Company. The mines in Franklin county are owned by the Western Coal and Mining Company and the Doddson Coal Company. The mines in Johnson county are owned by the Pennsylvania Anthracite Coal Company, Little Rock Packet Coal Company and Western Coal Company.

Colorado. (By John D. Jones.)—The total output of the various grades of coal in 1909 in Colorado amounted to 10,736,459 tons, which is an increase over 1908 of 963,452 tons, or 9.85 per cent., and shows that the market conditions have decidedly improved since 1908. The increase is considerably larger in the domestic than in the steam fuel. The Huerfano county product is classified as bituminous and noncoking, but is in reality a domestic coal and in great demand for its merits as such. Since 1907, Colorado has not been so heavy a consumer of steam coal as it had been for a long time previous to that date. The closing down of the metalliferous mines then and other steam plants depending upon the bituminous mines for their fuel supply has made the demand for this product rather dull. However, they are gradually resuming their normal activity and there will be a marked improvement in the demand for this grade of fuel. The increased demand for the domestic coals can be attributed to the large additional acreage of farming land placed under cultivation, resulting in the growth of the population and the bountiful crops harvested. Therefore, the increase was only normal and what could be reasonably expected. Yet in the face of this growth of the industry, the operators complain of 1909 as being a lean year for them. This probably was due to the fact that a number of large producing mines were opened about a year ago, putting out large quantities of coal, dividing the business and quickening competition.

There was an increased demand for domestic fuel in the adjoining prairie States to which much of our coal is shipped, with the possible exception of Texas, which I understand has not taken as much of our product as expected on account of the drought and consequent crop failure. Colorado ships coal to Nebraska, Kansas, Texas and other States where the freight rates are not prohibitive to competition with neighboring coal-producing States. Colorado being situated further away, the rates are higher than those of other States, which is a handicap to our shippers, and it is only due to the superior quality of Colorado coals that this difference in the freight rates can be overcome. There has been considerable agitation in this State for a lower freight rate, and should the railroads make concessions the market would expand proportionately. Owing to overproduction and a slack demand for fuel, a coal war was waged in the lignite districts of Boulder and Weld counties, which resulted in a reduction of 50c. per ton and lasted from February to November 22, when a truce was declared and the old prices were resumed. This probably had the effect of increasing the Boulder county output, while in Weld county it caused the production to fall below that of 1908. The prices in the other districts were not affected.

In the early autumn there was a decided shortage. No labor troubles occurred in any part of the State, and the wage scale of a year ago prevailed. The coke industry showed a marked increase. Much development work was done at the Oak Hills and Pinnacle mines, situated on the Moffat road in Routt county. The former has attained a monthly output of 15,000 tons and the other at present 2500 tons. From 3000 tons in 1908, Routt county has increased to 89,900 tons. Outside of these two mines, no other mines of any consequence have been opened up in this district. The following summary gives a fairly accurate digest of the industry during 1909: Number of mines in operation, 193; tons of lignite coal produced, 2,150,280; tons of semi-bituminous coal produced, 842,927; tons of bituminous coal produced, 7,612,308; tons of anthracite coal produced, 60,944; tons of unclassified coal produced, estimated, 70,000; total tonnage produced, 10,736,459; increase over 1908, 963,452; tons of coal mined by hand, 9,107,349; tons of coal mined by machine, 1,629,110; total number of mining machines used, 198; total tons of coke produced, 1,091,882; total total number of coke ovens, 3309; number of employees in and about the mines, 13,156; number of employees at the coke ovens, 1089.

Idaho. (By F. C. Moore.)—Idaho contributes but slightly to the coal production of the country, there being but two districts in which coal was mined during 1909. The only deposit of importance which contains a good grade of bituminous coal is found in Fremont county. The Brown Bear coal mine in this section produced about 1500 tons of high-grade bituminous coal during the year, which averaged approximately as follows: Fixed carbon, 55.65 per cent.; volatile carbon, 36.62; moisture, 3.13; ash, 4.10; sulphur, 0.50. Total, fuel contents, 92.00 per cent. This property has 12 coal measures exposed upon it varying from one to ten ft. in thickness, but it is so remotely situated from transportation that its production has been confined to supplying local demand. There are no difficult engineering feats to be accomplished in the building of a railroad to this district, as a water grade could be obtained with no heavy work. The coal measures are in an unaltered sedimentary formation of Cretaceous age; are a continuation of the series mined farther southeast in Wyoming, and if properly opened and equipped could supply the total coal demands of the State for years to come. The only other producing coal property in the State is at Salmon City, which sold during the year about 2000 tons of lignite coal, all of which was consumed locally. A large portion was used by the Pittsburg & Gilmore railway in the operation of steam shovels. Numerous showings of lignite coal are found at various portions of the State, but upon which little work has been expended.

Illinois.—The total coal output of all mines in Illinois for the year ending June 30, 1909, was 49,163,710 short tons. This production shows a decrease of about 110,000 tons as compared with the output of the preceding year. Coal was produced in 55 counties; there were 384 shipping or commercial mines, as compared with 407 shipping mines in 1908. The average value of the coal per ton at the shipping mines was $1.012; the aggregate home value of the product was $50,303,757. For haulage purposes underground there were 210 motors, 73 horses and 5527 mules. Mining machines were used in 107 mines, as compared with 105 mines in 1908. About 16,000,000 tons were undercut by machines, while 33,000,000 were mined by hand. There were 66,374 persons at work underground, while 6359 men were employed on the surface. The average price paid per gross ton for hand mining was 59c.; the average price paid per gross ton for machine mining was 46c. More than 1,280,000 kegs of powder were used for blasting coal. The number of men accidentally killed totaled 213, while of this number 14 were killed outside of the mine. The number of men killed to each million tons of coal produced was 4.3, as compared with 3.7 in 1908.

(By F. W. De Wolf.)—The coal mining industry in Illinois in 1909 recovered from the setback of 1908, when the production decreased over 3,000,000 tons from the 1907 production. Among the important events of 1909 was the Cherry mine disaster, which has been already described in various publications. This sad accident has had the effect of stimulating a revision of the mining laws by a special session of the Legislature. Three bills are now assured of passage. The first requires suitable fire-fighting equipment in mines and fire drills. The second requires the establishment of three mine rescue stations for the drilling of a rescue corps for use in emergencies. The third, the establishment of mining institutes. with provisions for the education of American and foreign miners along the lines of safe and efficient methods. According to statistics prepared for publication by David Ross, secretary of the Bureau of Labor Statistics, the total production for the year ending June 30, 1909, exceeds 49,000,000 tons, and fell but slightly below the values for the previous year. The total of mines similarly decreased from 922 to 886. There are 55 coal-producing countries.

Future development of considerable magnitude is indicated by drilling operations now in progress in certain parts of the State. Large interests are said to be behind development in Franklin county, where several crews of drillers have been engaged a year or more in the territory north and east of Benton. Extensive prospecting has also been under way in Bond and Madison counties in the vicinity of New Douglas, and in Christian and Shelby counties south of Pana. New prospects have been opened at Lovington, in Moultrie county, at Norris, in Fulton county, at Mather, in Mercer county, and in the St. Libory field, in St. Clair county. New development is partially counteracted by the abandoment of several large mines and the suspension of others because of accident. Among the serious accidents of the year the Cherry disaster, with the reported loss of 268 men, of course, was most important. Other serious disasters occurred, however, in the vicinity of West Frankfort and Herrin. In all of these cases and in other serious mine fires the use of oxygen helmets from the Urbana sub-station of the United States Geological Survey were used with conspicuous success.

Indiana.—Although the production of coal of the Indiana mines was materially decreased in 1908, as compared with 1907, the output for 1909 was almost equal to that of the banner year. The improved facilities adopted by some of the older properties and the operation of a number of new mines occasioned a substantial increase in production over the previous year. A portion of this development of the industry was due to the extension of railroad facilities and a more adequate car service, but the primary and general cause of increased production was the rush of orders due to returning prosperity, and the unusually large consumption of Indiana coal by the United States Steel Corporation's immense plant at Gary, Indiana.

The gradual improvement in the productive capacity of the miners, on account of a more general use of coal mining machinery, has been perceptible in a large degree. The machine-mined product has increased in this State until only a few States outrank Indiana in the percentage of machine-mined coal as compared to the total output. The selling price for bituminous coal during 1909 averaged about $1.25 per ton for mine-run, while the block coal prices averaged nearly $2.40 per ton. According to the monthly reports, about the same number of men were employed as in 1908, namely, 19,100, to whom was paid an aggregate of $10,500,000 in wages.

Ten new mines were opened, and five mines formerly closed or abandoned were reopened during the year. The new mines and the rejuvenated mines are pretty well distributed over the 18 producing counties of the State. The drilling for oil in the western portion of the coalfield has resulted in locating excellent coal beds, and the work of developing the finds is progressing rapidly in several locations. It is generally conceded that the number of mines in the western portion of the field will be increased 10 per cent. within a year.

Twelve mines were abandoned during the year, as against 28 the previous year. Various causes were assigned for the abandonment, the principal one, perhaps, being the flooding by reason of high waters during the spring months.

Fatal accidents were fewer and the number injured decreased materially in comparison with the record of 1908. The fatalities reported were found to be due, for the most part, to the carelessness of the miners and their wanton disposition to violate the provisions of the law intended to protect them from injury or death. Illegal shot-firing was found to be a common cause of a majority of the accidents reported to the Department of Mining. The recklessness and disregard for laws of safety exhibited daily by the miners when using explosives seemingly increased during the year. Strikes and labor troubles were less frequent than during the previous year. The controversies arising over provisions of the wage contract were few and of short duration.

Iowa. (By James H. Lees.)—The coal industry of Iowa was marked during 1909 by a gradual recovery from the effects of the financial and industrial depression of 1907-1908. In 1909 some of the new mines increased their output and the results of extensive prospecting and development became evident in the larger tonnage. Another factor which contributed to an increased output in 1909 was the fact that there were no serious strikes or other disputes, and that freedom from these was practically assured by the agreement between the miners and operators regarding wages and other conditions. This agreement was made in April, 1908, and while it was pending considerable time was lost by the mines being idle. The agreement terminates on April 1, 1910, and it is to be expected that a similar cessation of activity will tend to reduce the production somewhat during 1910. Aside from this, however, the indications are that the industry will at least retain its present position. There will be probably considerable development work in 1910, as several fields have been thoroughly prospected and found to be underlain by large bodies of coal. Parts of Monroe and Lucas counties seem to give the best promise of any undeveloped coalfield in Iowa. Monroe county has ever since the opening of the present century been the leading producer, and in 1909 it maintained its lead with an output of 2,200,000 tons, while its nearest competitor, Polk county, had a showing of about 1,700,000 tons.

The statistics gathered by the Mine Inspector's office show that during the fiscal year ended June 30, 1909, there was a decided increase in the quantity of coal mined and also in the number of men employed, in the first and third inspection districts, over the previous year. The second district, however, shows a rather sharp decline in the output and also a slight reduction in the number of employees. The estimates for the calendar year 1909 show that the upward tendency is quite marked all over the State. According to these figures the output for the fiscal year 1907-1908 was 7,155,435 tons; for 1908-1909, 7,346,252 tons.

Three hundred and seventeen mines were operated in 1909, being about evenly divided between local and shipping mines. A reduction is shown from the preceding year, when 333 mines were in operation, 157 of them doing a shipping business and the remaining 175 depending on the local trade. The total number of persons engaged in mining was 18,200 in 1909, as compared with 17,312 in 1908. Accidents to miners were of about the same frequency as in the preceding year. No figures are yet available for exact comparison. The use of mining machinery was less extensive than it was in 1908, as all the machines in the first district have been taken out following an arbitration board's ruling advancing the price of loading machine-mined coal. In the second district also the number of machines in use has decreased. Whereas, two or three years ago five companies employed machines, at present only two are continuing their use. Perhaps a word regarding the southwestern Iowa field may be in place. The coal here is in the Upper Coal Measures, and, unlike that of eastern Iowa, which is in the Lower Coal Measures, lies in one continuous seam. It is only 12 to 20 in. thick, and while the market is good, the output is diminishing annually owing to the scarcity of labor, which in turn is caused by the difficulty of mining. The output from the three counties in which mining is carried on amounted to 41,000 tons, in securing which 245 men were employed. The price at the mine ranges from $2.50 to $3.50 per ton, varying in different localities.

Kentucky. (By C. J. Norwood.)—The output of commercial coal for the calendar year 1909 amounted to 10,296,145 short tons, the production for each district being as follows: Western, 10 counties produced 5,578,161 tons; southeastern, 5 counties produced 3,342,130 tons; northeastern, 9 counties produced 1,375,854 tons. Of the total output, 70,998 tons were of cannel, all of which came from the mines of the northeastern district. The disposition of the product was as follows: Sold locally, 377,059 tons; used at the mines, 291,950 tons; made into coke, 86,964 tons; shipped to market, 9,540,072 tons. Compared with those for 1908, the returns show a gain of 490,368 tons. They are only 139,916 tons less than the output for 1907 (10,436,061 tons), which was the largest in our history. The increase was all in the eastern field. Each district there made material gains, not only over the output for 1908, but over that for 1907. The western district shows a loss of 582,621 tons when comparison is made with the output for 1907, and of 56,435 tons when comparison is made with that for 1908.

Twelve counties produced 200,000 tons or more each; eight produced 50,000 to 100,000 tons each, and four produced less than 50,000 tons each. Those that produced 200,000 or more tons, respectively, come in the following order: Muhlenberg, Hopkins, Bell, Whitley, Pike, Knox, Ohio, Webster, Union, Laurel, Johnson and Henderson. Until 1908 Hopkins county held first place. The advance of the counties that lie within the eastern coalfield since 1904 is instructive. Pike county began producing commercial coal in 1904, and held twentieth place in that year; in 1905 it moved to fourteenth place; in 1906 to tenth; in 1907 to eighth; in 1908 to seventh, and in 1909 to fifth. Its production will doubtless soon reach the million-ton mark. Johnson county has advanced from twenty-third place in 1904 to eleventh in 1909, and the prospects are for a material increase in its production within a short time. Floyd county also shows good progress. It began producing commercial coal in 1906, when it occupied twenty-sixth place. In three years it has moved to sixteenth place. In 1904 Bell county, now third in the list, held fifth place.

For statistical and trade purposes, a distinction is made between cannel and other varities of bituminous coal; the cannel is treated as a separate grade, and the other coal classed simply as bituminous. The total selling value of the combined product (cannel and bituminous) at the mines was $9,698,832, giving an average of 94.19c. per ton. This was a decrease of 5.51c. from the price of 1908. The figures show a decrease of 5.41c. in the average value for all districts, when compared with that for 1908. The average value for the western district shows a decrease of 7.92c., and that for the southeastern district shows a decrease of 5.31c.; the average value for the northeastern district shows an increase of 0.97 of a cent. The total value of the 70,998 tons of cannel produced was $174,524, giving an average of $2.458 per ton at the mine. This is a slight increase over the value for 1908. Of the total output, 58.30 per cent. was mined by machines. The western district shows a gain of 474,346 tons in the machine-mined tonnage, and a gain of 9.17 in the percentage. The southeastern shows a decrease of 81,125 in the tonnage, and a decrease of 5.26 in the percentage. The northeastern district shows a gain of 90,266 in the tonnage, but a decrease of 2.63

in the percentage. Compared with outward shipments for 1908, there was an increase of 592,491 tons in the amount of coal shipped to other States.

But little coke was made. The production, in short tons, was 38,849. The production of the Marrowbone Coal and Coke Company, at Lookout, Pike county, is worthy of note, since it marks the beginning of coke-making in the Elkhorn coalfield. At the close of the year that company had 10 ovens burning, with 90 more in contemplation for 1910. The Elkhorn Consolidated Coal and Coke Company had plans for the erection of 250 ovens, and the Mitchell Coke Company also had the building of ovens under consideration. The latter companies are at Hellier, Pike county.

The tonnage of commercial coal for 1909 was produced by 230 companies, employing 18,776 persons, of whom 14,958 worked underground The number of hours constituting a working day ranges from 8 to 9 and 10, depending upon the locality. For the sake of uniformity in statistics all days are here reported as 10-hour units. The average number of 10-hour days worked per separate operation in the western district was 139; in the southeastern, 170, and in the northeastern, 173.

In the production of the coal, 121 noteworthy accidents occurred in the mines, 3 in shafts, and 8 on the surface. Of the inside accidents 33 were fatal, 37 were serious, and 51 of minor character. For each death by accident in and out the mines, 302,828 tons of coal were produced. This was an increase of 57,709 tons over the amount for 1908. For each 1000 persons employed in and out there were 1.810 deaths by accident in 1909, as against 2.149 in 1908. Kentucky still stands in the front rank with States having the smallest number of mine fatalities. In consequence of the disaster at the Browder mine in February, however, the record for 1910 will not be good. The number of accidents due to falls of top is altogether too great. It is unquestionably largely due to use of excessive charges of powder and to shooting "on the solid," a practice which should be prohibited by law. Solid shooting and the use of excessive amounts of powder shakes the roof throughout the mine and will soon ruin the best of roofs.

The accident which caused the death of seven men as the result of an explosion of gas was one of the most remarkable the mining industry has known. It occurred at the Baker mine, in Webster county, in December. There are two seams of coal at that mine, one of them 120 ft. below the other, and the upper one 90 ft. below the surface. They are connected by a shaft. The coals have a dip of about 4 deg. Both seams have been worked. In 1906 or 1907 work was suspended in the lower seam, and the lower mine allowed to fill with water, which extended up the shaft 103 ft. at the time of the explosion. The lower mine makes considerable explosive gas, but the water was expected to seal it off from the upper works. On December 11, after the "run" was over, a column of water accompanied by gas suddenly shot out of the shaft, the gas was in some manner ignited, a series of explosions occurred, the heat of the explosions converted some of the water into steam at the shaft, and the steam rushed into the upper mine and burned and suffocated seven men who were working there. The men had nothing to do with setting the gas on fire, and there were no naked lights near the shaft in the upper mine; the ignition of the gas occurred at the surface. There was nothing in the condition of the mine in which work was in progress to cause an explosion. To provide against the recurrence of such an accident, bore-holes have been put down to drain the lower mine of gas and allow water to reach quite to the faces of the coal.

During the recent session of the Legislature an appropriation was made for the purchase of six sets of rescue apparatus, for use at mines in event of explosions or fires. This wise provision is fully appreciated by the mining interests. Thanks are due Senator Salmon who introduced the bill in the Senate, and to Mr. Colson who championed it in the House; also to the Governor, who heartily approved the measure at all times. The apparatus will be purchased as soon as the act goes into effect. It is interesting to note the fact that after June 15, no service certificates will be granted to men desiring to act as mine foremen. Under the terms of the Colson bill, certificates can be obtained only upon examination.

Michigan.—The production of coal in Michigan in 1909 showed but little change over that in 1908. During 1909 there were about 130 mining machines in use in the coal mines of Michigan. Approximately one-third of the total coal output is machine-mined. About three-fourths of the machines used are of the pick or puncher type; the remaining machines are of the chain-breast type. Practically all of the coal used in Michigan is consumed in the manufacturing plants along the lake fronts, and the prosperity of the industry depends almost entirely on the degree of prosperity enjoyed by local business concerns.

Missouri. (By Geo. Bartholomaeus.)—The output of coal for Missouri during 1909 was 3,787,431 tons or an increase of 386,787 tons over 1908. Macon county, which, for a number of years ranked first in the production of coal, shows a decrease of 34,224 tons for 1909. Lafayette county, the second largest coal producing county in the State, reports an increase of 152,020 tons, while Adair county, which in 1908 was practically on a par with Lafayette county, produced 114,814 tons less in 1909 than in 1908. Beside the big increase in production reported by Lafayette county, other counties showing substantial gains in production are: Barton, Clay, Henry, Howard, Linn, Montgomery, Platte, Ray and Sullivan.

Montana.—The State coal mine inspector recently submitted his report for 1909. The total output for the year is estimated at 2,541,679 tons as against 1,979,417 for 1908. This increase was due to larger production in the old mines rather than to the opening of new properties. A total of 3862 men were employed in the industry. The inspector urges the necessity for fire drills in the mines as a means of averting accidents. Legislation is urged providing for avenues of escape from the mines when the main shaft becomes blocked, and providing for underground refuge rooms where the men may be safe from gases and floods.

(By W. P. Cary.)—The more important of the coal mines in Montana were operated by the several railway and large copper-mining companies in 1909. Carbon county had a number of active producers during the year, among which were the Washoe Copper Company's mines at Bear creek, the Northern Pacific Railway Company's mines at Red Lodge and the Bridger Coal Company's mines. In Yellowstone county, the Chicago, Milwaukee & Puget Sound Railway operated mines at Roundup, and in Casade county the Great Northern Railway's mines at Sand Coulee produced their usual tonnage. In Deer Lodge county, the Bielenberg and Higgins mines were the principal producers.

Nebraska. (By Erwin H. Barbour.)—The history of early prospecting and coal mining in Nebraska has already been recorded in Part 7 of Volume III of the Nebraska Geological Survey, and will not be mentioned here, nor shall I temporize on the utter futility of "mining on hope," as they have done for so many years, and still persist in doing in this State. To be brief, the present status of coal mining in Nebraska may be summed up as follows:

Though many mines have been opened and closed in quick succession, actual coal mining, for such it may be called, began in the Honey Creek Coal Mine, near Peru, February 11, 1906. Careful measurement made at a number of points show a bed of coal varying from 29 to 35 in. In the new tunnels a thickness of 37 in. is claimed by the owners. Verified measurements show an average of 33 in. throughout the old tunnels. From March, 1908, to December of the same year the mine was closed on account of fire and subsequent flooding until November, 1908. Work was resumed in December of that year. From February, 1909, to September of the same year, owing to fire and "cave-ins," work was again suspended. A new company has been formed and mining operations are to be resumed in 1910. For years the Legislature of Nebraska has offered a bounty amounting to $4000 for the discovery of a 26-in. bed of workable coal in the State, and $5000 for a 36-in. bed, and the last Legislature met this obligation, as the preceding Legislature failed to do, by paying the bounty through the Claims Committee.

The total coal production for 1906 was 200 tons valued at $839; for 1907, 646 tons, $2260; for 1908, 161 tons, $563.50; for 1909, 111 tons, $384.25. The amount of coal in this mine is estimated to be 250,000 tons, and it is not unlikely that when exhausted its continuance in neighboring hills may be proved. The fact that a coal mine is in operation here does not in any way invalidate the beliefs and statements of geologists that coal in commercial quantities cannot be expected in Nebraska.

New Mexico.—The year 1909 showed a healthy condition of the coal-mining industry in the Territory. The gross production was 3,010,000 tons, an increase of 237,414 tons over 1908, or about 10 per cent. Of the gross product 35,000 tons was used in operating the mines; the small quantity used for operating is explained by the fact that in the largest producing camp, Dawson, the waste gases from the coke ovens are conducted at high temperature to the boiler plant and furnish the fuel for necessary power at the mines, as also for heating many of the larger buildings. At some of the smaller mines slack is used for boiler fuel and no account of it is kept. The net production, deducting fuel used for operating the mines, was 2,975,000 tons. Of this total net product 2,175,000 tons was shipped to market and was sold at an average price of $1.50 per ton at the mine, or a total of $3,262,500, the price ranging slightly higher than in the preceding year, which was $1.40 per ton; the price strengthened materially in the fall and winter months.

About 800,000 tons of unwashed slack and coal were sent to the washeries and thence to the coke ovens, where 430,000 tons of coke were made from it, which sold for $3 per ton at the ovens, or a total value of $1,290,000. The total value of coal and coke was $4,552,500. The demand for coal for domestic purposes and for railroad use became so great in November and December that some of the coke ovens were closed, as it was more profitable to sell the coal than manufacture coke at prevailing prices. While the tonnage of coal produced was greater than in 1908, there was a less number of men employed in and about the mines; 2550 men being employed underground and 550 outside; 34 boys worked underground and 28 outside, a total of 3162 persons employed at the mines; this compares with 3200 men underground and

740 on top, making a total of 3940 men and 120 boys, or 4060 persons employed in 1908.

The greater production with the less number of men is accounted for by the fact that during the preceding two years the majority of the miners were engaged in development work, or narrow work, while 1909 had the advantage of an ample number of rooms which were turned during the two previous years of the initial development stage. The majority of the miners being employed in rooms allowed a greater production per man than in the previous years when on narrow work. The same is true of the men employed on top; the equipment was perfected and it required fewer men to handle the product at the surface. Thirteen men were killed in the mines during the year, or 4.11 for each 1000 persons employed, or 0.411 per cent. for 1909; this compares with 21 killed during the preceding year, or 0.517 per cent., a gratifying decrease, but not as good as it should be. Six of the fatalities were due to falls of rock; three by falls of coal; two by being run over by mine cars, and two smothered by smoke from mine fire.

North Dakota. (By A. G. Leonard.)—According to the State Mine Inspector, the production of coal in North Dakota in 1909 was 354,305 tons, an increase of 36,465 tons over 1908. The number of mines in operation was 110, and the number of men employed in mining operations was 850. There are 12 coal-producing counties, all of them in the western part of the State, but half of these produce only a few hundred or few thousand tons. Two-thirds of the total output came from two counties, Burleigh and Ward, and these are followed by Stark, Williams and Morton counties, named in the order of their importance. Ward county contains the greatest number of mines, or 47 in all. Fourteen mining machines are in use in four mines of the State. Several new mines have been opened up in southern Adams county, near the line of the Chicago, Milwaukee & Puget Sound Railroad. They work a 12-ft. seam, the coal of which is reported to be of exceptionally good quality.

The coal fields of North Dakota cover an area estimated at approximately 32,000 sq. miles, and the total tonnage of workable coal has been estimated at 500,000,000,000 tons. In Billings county alone there are known to be at least 21 coal beds, distributed through from 1000 to 1300 ft. of strata, and having an aggregate thickness of 157 ft. Some of these beds are known to cover an area of from several hundred to over 1000 square miles. Beds of coal 6, 8 and 10 ft. thick are common, those from 10 to 20 ft. thick are not rare, while beds over 20 ft. thick are seldom found. The Sentinal Butte bed is 21 ft. thick, and that on Sand Creek has a thickness of 35 feet.

The North Dakota coal is mostly a brown lignite with a decidedly woody structure, exhibiting clearly the grain of the wood and having the toughness of that material. The lignite of some seams breaks or splits readily along the grain, but is broken with difficulty in other directions. Portions of flattened trunks and branches are often found in the beds, bearing a close resemblance to the original wood except for the brown color. The same bed is frequently more woody in some portions than others, being made up of alternating layers of tough brown lignite, and black, lustrous brittle material. The coal is often cut by one or two systems of joints which are vertical, or nearly so, and from 5 or 6 in. to one foot or more apart. These joints are usually very clear cut and regular. On exposure to the air the lignite looses much of its moisture, begins to crack, and finally breaks up into small fragments.

(By T. R. Atkinson.)—North Dakota, long known only as an agricultural State, is slowly beginning to realize, in the light of recent investigations, that there are immense possibilities in the development of the lignite field. The United States Geological Survey estimates that 32,000 sq. miles, or nearly one-half of the area of the State, is underlaid with workable beds of lignite, and the probable tonnage is placed at 500,000,000,000 tons. This is far in excess of the estimated tonnage of any other State in the union, and it comprises an immense store of fuel that will prove of untold value in future years. The lignite bearing strata of the North Dakota field is referred to either the Laramie formations of the late Cretaceous period or the Fort Union beds of the early Tertiary. Because of the similarity of these beds, and the difficulty of obtaining sufficient evidence definitely to describe them as either one or the other, this has been an unsettled question, but the present consensus of opinion among geologists favors their classification as Fort Union depositions. In Billings, Bowman, Dunn and McKenzie counties, in the southwestern portion of the State, due to the Bad Land structure, caused by the erosion of the Little Missouri river and its tributaries, there are many clean cut sections where numerous beds of lignite are exposed alternating with beds of clays, sands and loosely cemented sandstones. These beds of lignite vary in thickness from a few inches to 35 ft. of clean coal. Exposed sections of lignite-bearing rock, totaling 900 ft., are found, and added to these, the 800 ft. pierced by the Northern Pacific Railroad Company's well at Medora, makes a total of 1720 ft. Evidences of the extensive combustion at some past period of big beds of coal are furnished by the numerous layers of clinker or red clay, commonly called scoria.

North Dakota lignite is generally free from sulphur, contains less than 8 per cent. of ash, about 50 per cent. of fixed carbon, 30 per cent. of volatile matter, and 20 per cent. of moisture. Its heating value is 65 per cent. of that of the best Pennsylvania bituminous coal, and no clinker results from its burning. Since lignite on its exposure to the air rapidly loses moisture, slacking takes place, reducing the coal to a fine material, incapable of being burned on a grate, except with a forced draft, its value would necessarily be greatly increased by briquetting. In this manner the superfluous moisture would be disposed of and the resulting product could either be stored or shipped without loss of weight or slacking. To this end the fuel testing department of the United States Geological Survey at Pittsburg has conducted extended experiments in the briquetting of lignite, and the 1909 Legislature of the State appropriated a sum for the establishment and maintenance of an experimental station under the direction of the State School of Mines, while private enterprise has made and is making numerous attempts to solve the problem. The possibilities in doing this are seen when it is remembered that North Dakota is essentially a prairie State, dependent upon distant States for its supply of fuel and on railroads for its transportation hither, which results in a very high priced fuel for the consumer. Lignite briquets, which are cleanly to handle, free burning, of a uniform size, and with loss by slacking eliminated, would find immediate market in which they could successfully compete with any imported fuel. The results of the investigations of the United States Geological Survey undoubtedly proved that the most important economic method of handling lignite is in the production of producer power gas. These show that North Dakota lignite burned in the gas producer will develop much more power than any of the eastern bituminous coals burned on a grate.

It has been shown that 4.46 lb. of Virginia anthracite or 3.97 lb. of Ohio bituminous are required to develop 1 h.p. per hour in the steam engine, while 1 h.p. per hour is furnished by the consumption of 2.29 lb. of lignite when burned in the gas producer. This would make possible the production of a very cheap electrical power at the mines, which could be transmitted to all parts of the State for commercial purposes. The present market for lignite is practically only of a local nature, as but 24 of the 110 mines operating in 1909 shipped coal at all. The maximum number of men employed during 1909 was 920, while during the summer months there were but 320, and the total production was only 354,000 tons. The lignite industry can only be considered as in its infancy.

Ohio. (By George Harrison.)—The coal industry in the State of

Ohio for the year 1909, while showing a perceptible increase in tonnage over that of 1908, yet was far from equalling the high tide production of the year 1907, when it amounted to almost 32,500,000 tons. The returns for 1909 show that the production was 27,756,192 tons, an increase of about 1,500,000 tons. The Hocking Valley district (Athens, Hocking and Perry counties) shows a loss in tonnage, while Eastern Ohio (Belmont, Harrison and Jefferson counties) reported an increase of over a million tons. The most notable gains were reported from Jefferson, the total production being 4,056,158, or a gain of 491,156 tons; Belmont, 5,993,419, a gain of 401,700 tons; Guernsey county, over 3,000,000 tons, a gain of over 182,000 tons; Athens county, 4,300,000, a gain of 183,000 tons. Belmont county ranked first in production, Athens second, Jefferson third, Guernsey fourth, Perry fifth, and Tuscarawas sixth. The machine tonnage for the year amounted to 23,147,020 tons, a gain of over a million and a half tons; the pick tonnage, 4,609,172 tons, a loss of over 67,500 tons. One hundred and fifteen accidents were reported for the year, an increase of three; 68 by falls of roof, 20 by mine cars and 5 by premature explosions and explosions of powder, and 4 by motors. Over 240,000 tons of coal were mined to each life lost.

(By J. A. Bownocker.)—The past year has been of moderate activity only. This was due in part to the business depression during the first part of the year, and later to a shortage of cars. The latter has been felt particularly in the Hocking Valley field since the two principal roads that penetrate that field have West Virginia connections. The thicker seams and better coal in the latter State and the cheaper labor give an advantage, and it is claimed that the roads favor those mines with cars in preference to those of Ohio. A number of mines have been opened in the Massillon field where the Sharon or No. 1 seam has long been worked. The coal is of excellent quality and commands a ready market, especially in Cleveland. The field, however, is small and its life will be short. Two mines were abandoned within the year. The same seam is found in workable quantity near Jackson in the southern part of the State, and one mine was opened there. The Wellston or No. 2 seam, has long been recognized as the finest coal in Ohio. It has passed by far the zenith of its production. No new mines were opened in it and one was abandoned. The Clarion or No. 4 seam had a very quiet year. In workable thickness this coal is restricted to small parts of Jackson, Vinton, Lawrence, Gallia and Scioto counties. Its development has been retarded by the famous Wellston seam, but with the exhauston of the latter its day will come. Two new mines were opened, but three or four were not worked during 1909, and may be permanently abandoned. The Lower Kittanning or No. 5 seam is of workable thickness at a number of places and especially in the southern part of the State. Its development has been retarded by the neighboring Wellston field, but with the decline of the latter its production should increase. One mine was added to the list within the past year. The No. 6 or Middle Kittanning is one of the two great seams of Ohio. It can readily be traced across the State, and is of mining thickness in every county. The Hocking Valley field relies almost wholly on this coal, and it has been mined there in a very large way for more than 40 years. The field comprises Hocking, Perry and Athens counties, but the last is by far the largest producer. In spite of discouraging conditions six new mines were opened within the year, all in Hocking county. A few mines also prepared to open and should be producing before the close of 1910. Only two mines were reported abandoned within the year. The same seam is worked in southern Muskingum county, where one mine was added. Farther northeast in Coshocton and Tuscarawas counties the seam is largely worked, and each county added one to its list of shipping mines. The two counties, however, abandoned two or three mines, so the result is a stand off for the year.

The one great field of the No. 7 or Upper Freeport coal is in Guernsey and Noble counties. It extends in a general way between the two county seats, Cambridge and Caldwell. The field has long been extensively worked and may be said to be at its zenith, perhaps past it. No new mines were opened within the year and two were abandoned. The coal is soft and so does not bear handling well. It is used for general purposes. In the great Pittsburg field of eastern Ohio there were no notable features within the year. No new mines were opened nor were any abandoned. This district is now the most important in the State, and contains the largest area of undeveloped coal in Ohio. Probably it will be an extensive producer after the fields already mentioned have been exhausted. The year in the Pomeroy or Redstone district was quiet. The producing territory is limited to Pomeroy and vicinity, the coal thinning rapidly to the north and west. Eastward it is below drainage, and information concerning it is very meager. One new mine was added and no shipping mine was abandoned.

Pennsylvania.—The total production of coal in Pennsylvania in 1909 was 213,246,575 short tons, which is a material increase over the output of the preceding year. Of Pennsylvania's total production, 77,040,880 tons were anthracite coal. The results show that the production of bituminous coal increased considerably during the year, while the output of anthracite was slightly less than in 1908. The anthracite trade was under the influence throughout 1909 of conditions relating to the renewal of the contract with labor which expired April 1. Preliminary to that date a large amount of coal was mined and put into stocks, to be prepared for a strike, which did not occur. The large amount of coal above ground was somewhat of a handicap, and resulted in causing artificial restriction of tonnage. The year was an advantageous one to owners of anthracite securities. A number of companies increased their dividends and several made large extra distributions. Jersey Central made a distribution of 22 per cent. Lehigh Coal and Navigation made a valuable allotment of stock worth 11 per cent. and a stock dividend of 15 per cent., which latter was worth 30 per cent. in the market, besides increasing the dividend to 10 per cent. per annum. Reading increased the dividend on the common stock to 6 per cent., Lehigh Valley made 6 per cent. the regular distribution instead of 4 per cent. and 2 per cent. extra. Delaware, Lackawanna & Western paid 20 per cent. regular dividend, 15 per cent. stock dividend, and an extra cash dividend of 50 per cent., with the right to subscribe for 25 per cent. of holdings in the stock of the Delaware, Lackawanna & Western Coal Company. Lehigh & Wilkesbarre Coal Company declared an initial dividend of 6½ per cent. Anthracite coal no longer enters to any great extent into manufacturing industries, and as a consequence, is less seriously affected by financial depressions. Approximately, 350,000 men were employed in the coal mines of Pennsylvania in 1909. Of this number 175,000 were in the anthracite mines. The average annual production per man in the anthracite mines in 1909 was 475 short tons; in the bituminous mines, the average annual production per man was 710 tons. Practically all of the smaller sizes of anthracite which were formerly wasted are now used for heating and power purposes in office buildings, hotels, etc. The number of mining machines employed in the bituminous mines increased during the year, and it is estimated that about 5300 undercutting machines are now in use. Approximately, two-thirds of all the machines used are of the pick or puncher type. Pennsylvania still retains its leadership as the chief coal producing State. Its output of bituminous coal in 1909 exceeded the combined production of Illinois, West Virginia and Ohio, which are the next largest producers. The State of Pennsylvania alone produces more coal than any single foreign country, except Great Britain. It is estimated that about 17,000,000,000 tons of anthracite coal remain unmined, while good authorities figure that about 110,000,000,000 short tons of bituminous coal remain unmined in Pennsylvania. The output of coke in the Connellsville region in 1909 was 17,785,832 tons against 10,700,022 tons in 1908.

Texas. (By Wm. B. Phillips.)—The production of bituminous coal in Texas in 1909 was 1,144,108 short tons, valued at $2,714,630. This is the largest production in the history of coal mining in Texas. In the year 1895, when separate returns of coal and lignite were first rendered, the production of bituminous coal was 360,616 tons, valued at $801,230.

PRODUCTION AND VALUE OF COAL AND LIGNITE IN TEXAS, 1895–1909. (*a*)

Year.	Coal.		Lignite.	
	Tons.	Value.	Tons.	Value.
1895......	360,616	$801,230	124,343	$111,908
1896......	376,076	747,872	167,939	148,379
1897......	422,727	792,838	216,614	179,485
1898......	490,315	968,871	196,419	170,892
1899......	687,411	1,188,177	196,421	146,718
1900......	715,461	1,350,607	252,912	231,307
1901......	804,798	1,655,736	303,155	251,288
1902......	696,005	1,326,155	205,907	151,090
1903......	659,154	1,289,110	267,605	216,273
1904......	774,315	1,652,992	421,629	330,644
1905......	809,151	1,684,527	391,533	284,031
1906......	839,985	1,779,890	472,888	399,011
1907......	940,337	2,062,918	707,732	715,893
1908......	1,047,407	2,580,991	847,970	838,490
1909......	1,144,108	2,714,630	715,151	592,421
Total....	10,767,866	$22,596,544	5,488,218	$4,767,830

(*a*) The total production of coal and lignite during this period was 16,256,084 tons, valued at $27,364,374. The average value of the coal during this period was $2.10 per ton at the mines. The average value of the lignite was 86.6c. per ton.

THE PRODUCTION OF COAL AND LIGNITE IN TEXAS, 1884–1909. (*a*)
(In tons of 2000 lb.)

Year.	Production.	Year.	Production.	Year.	Production.	Year.	Production.
1884........	125,000	1891........	172,100	1898........	686,734	1905........	1,200,684
1885........	100,000	1892........	245,690	1899........	883,832	1906........	1,312,873
1886........	100,000	1893........	302,206	1900........	968,373	1907........	1,648,069
1887........	75,000	1894........	420,848	1901........	1,107,953	1908........	1,895,377
1888........	90,000	1895........	480,959	1902........	901,912	1909........	1,859,259
1889........	128,216	1896........	544,015	1903........	926,759		
1890........	184,440	1897........	639'341	1904........	1,195,944	Total.....	18,199,584

(*a*) These statistics, with the exception of the figures for 1909, are from the reports of the U. S. Geological Survey. The returns for 1909 were made direct to the Bureau of Economic Geology at the University of Texa by the producers.

For each ton of coal mined in 1895 there were mined 3.17 tons in 1909. In 1895 the coal was valued at $2.22 a ton, and in 1909 at $2.37. The production of lignite in 1909 was 715,151 tons, averaging 82.8c. per ton. There was a decrease in lignite of about 100,000 tons from the production of the year 1908. The coal producing counties are Erath, Palo Pinto, Parker, Wise and Young in the northern field, and Maverick and Webb in the southwestern field. Perhaps a better nomenclature would be Colorado and Rio Grande, as the northern field is north and northeast of the Colorado river and the southwestern field is along the Rio Grande. The lignite producing counties are: Bastrop, Fayette, Hopkins, Houston, Leon, Medina, Milam, Robertson and Wood. The latest estimates of the coal and lignite areas are those of M. R. Campbell, of the United States Geological Survey. He gives 8200 square miles of known coal area, while 5300 square miles in addition may contain workable seams. This is a total of 13,500 square miles of known and possible area. For lignite he gives 2000 square miles of known area and 53,000 square miles in addition that may contain workable seams. This makes 55,000 square miles of known and possible lignite area. The known coal and lignite area would thus be 10,200 square miles, with 58,300 square miles, in addition, of possible area. Mr. Campbell estimated that the original supply of coal in Texas was 8,000,000,000 tons, and of lignite 23,000,000,000 tons, or a total of 31,000,000,000 tons of total coal and lignite. We have mined over 18,000,000 tons of fuel, and have enough left for 3000 years, allowing that the production should be 10,000,000 tons a year instead of less than 2,000,000 tons. It is fair to assume a loss of 1½ tons for each ton mined, so that our total fuel loss has been about 27,299,000 tons. There need be no appprehensions whatsoever in respect of a failure of our fuel supply for at least 3000 years yet. The above tables show the production and value of the Texas fuel output in past years.

Washington.—During the year 1909, there were 48 mines producing coal in the State of Washington. The total production amounted to 3,261,227 tons. The mines of the Northwestern Improvement Company, at Roslyn, continued to produce the greatest tonnage of coal. Only three companies produced coke, and the total coke output during the year amounted to 42,335 tons. The mines operated a total of 272 days during the year. The total number of inside employees was 4420, while 1305 men were employed on the surface. Fatal accidents amounted to 39, while 136 miners were injured. The year's fatalities left 22 widows and 61 orphans. Seven mines were idle during the year.

West Virginia.—From the 713 producing mines operated by 391 firms, together with the small country mines, the coal produced during the fiscal year 1909 was 46,697,017 short tons; this output shows an increase over the previous year of 2,326,756 tons. The total production of coke was 3,125,451 short tons, an increase of 147,188 tons over the previous year. The total value of the coal sold was $34,480,134; the total value of the coke produced was $5,577,276. The coal mines of West Virginia in 1909 gave employment to approximately 58,000 men. The average production per man for the year was 750 short tons. There were about 1600 machines in use, of which number 625 were pick machines. The year was especially free from serious disasters. The supply of coal still available in West Virginia, allowing for a fair increase in the rate of mining, will last about 2000 years.

(By I. C. White.)—The most active region of the State in the development of new collieries is that along the Virginian Railway in Raleigh, Wyoming and Mercer counties, especially along the Winding Gulf Branch of this great railway. The new mines are all in the New river and Pocahontas series of low volatile steam and coking coals. Several new mines have also been opened in McDowell county in the Pocahontas series along the Norfolk & Western Railroad territory, as well as some new mines in the Kanawha series farther north in Mingo county by extension of branch lines up Mate creek and other streams. On the great Chesapeake & Ohio Railway system, much developmental work is also in progress, along a new line which this railway company is extending into the Winding Gulf region of Raleigh county in order to share in the rich freightage of New River coal which the Virginian Railway was the first to develop. The Coal River branches of the Chesapeake & Ohio Railroad are also developing new mines in the Kanawha series of southern Kanawha, and Boone counties, while branches from the Guyandot Valley lines in Logan county are opening up a great wealth of the Kanawha series fuel above Logan. It is reported that the Virginian Railway will be extended down the Guyandot from Mullins, at the mouth of Barker creek, during the season of 1910, so as to tap the splendid splint coals of Wyoming, Logan and Lincoln counties, and continuing on to the Ohio river at Huntington, and bridging over that stream, seek a lake terminal either through new construction or over existing lines.

In the northern portion of the State, the year 1909 was signalized by the entrance of some strong Pennsylvania coal corporations into the Pittsburg coal development of the Fairmont district. The Jamison Coal Company has purchased a large tract of Pittsburg coal, near Barrackville, Marion county, and is sinking shafts, and putting in a mining plant, coke ovens, etc., to cost over $500,000. Before the year closed this corporation also purchased for $3,200,000 the plant and coal acreage (7300) of the Georges Creek Coal and Iron Company, which adjoins its first purchase on the west. Not to be outdone in West Virginia investments, John H. Jones, president of the Pittsburg-Buffalo Company has also purchased 6000 acres of Pittsburg coal in Marion county, southwest from the holdings of the Jamison Company, and is arranging to open it up for shipments through the recently organized Four States Coal Company, both at the mouth of East Run on the main line of the Baltimore & Ohio Railway, and by extensions from the Monongah Branch of the Baltimore & Ohio up Tevebaugh and Little Bingamon creeks. Both the Jamison and Jones investments are supposed to be in the belt of low sulphur coals of which the Georges Creek Coal and Iron Company's product near Underwood is a type.

Wyoming.—About two-thirds of all the coal mined in Wyoming comes from what is known as the southern field or district No. 1. For the fiscal year ended September 30, 1909, this southern field produced 4,993,819 tons of coal; this output showed an increase over 1908 of 1,224,904 tons. The State of Wyoming is fast coming to the front as an important coal producer, and the 1909 production exceeded the output of any previous year. Miners in Wyoming are thoroughly unionized and the labor problem is a question of great importance in the Wyoming coal industry. Although miners were plentiful in 1909, it is likely that there will be a scarcity of labor in 1910 similar to what occurred in 1907. Approximately 25 per cent. of the coal production in 1909 was machine-mined. The chainbreast machine was slightly more favored than the puncher type.

Coal in Foreign Countries.

Australia. (By F. S. Mance.)—The record of the coal-mining industry in New South Wales in 1909, made a disappointing showing when compared with that of 1908, and the output for the year under review exhibits a decline of 2,127,146 tons and £734,497 in value. The decrease is especially noticeable in the shipments to over-sea ports, but the falling off in the output was chiefly due to a general strike of the miners which laid all the coal mines idle from November on to the end of the year, the principal mines only resuming operations in March, 1910. The coalfields in the other States are being more systematically opened up than formerly, and in Queensland and West Australia, particularly, a steady trade in bunker coal is being established. At Powlett river in Victoria, a coalfield of some extent has recently been opened up, the seams being proved by means of bores to be of good thickness and quality.

Canada. (By John McLeish.)—The total coal production in Canada in 1909, comprising sales and shipments, colliery consumption and coal used in making coke, is estimated at 10,412,955 short tons, valued at $24,-431,351. This is a smaller production than in either of the two preceding years. The western provinces each show an increased production of coal in 1909, but not sufficient to counteract the reduced output in Nova Scotia, which resulted from the coal miners' strike. The aggregate decrease for the whole of Canada was about 474,356 tons, or 4.4 per cent., while Nova Scotia alone showed a falling off of 968,789 short tons, or 14.6 per cent., the aggregate increase in the western provinces being 505,404 tons, or 12.1 per cent. Of the total production, Nova Scotia contributed 54.5, Saskatchewan and Alberta 20.5, and British Columbia 24.3 per cent.

PRODUCTION OF COAL IN CANADA.
(In tons of 2,000 lb.)

Province.	1907.	1908.	1909.
Nova Scotia	6,354,133	6,652,539	5,683,750
British Columbia	2,364,898	2,333,708	2,538,004
Alberta	1,591,579	1,685,661	1,978,843
Saskatchewan	151,232	150,556	163,329
New Brunswick	34,584	60,000	49,029
Yukon Territory	15,000	3,847	....
Totals	10,511,426	10,886,311	10,412,955

The total production of oven coke in 1909 was 875,080 short tons, valued at $3,557,147, being a slight increase over the production in 1908. At the ovens of the Dominion Iron and Steel Company at Sydney, a quantity of imported coal was used, the supply of domestic coal being insufficient on account of the strike. The Atikokan Iron Company at Port Arthur uses imported coal exclusively. At all other ovens Canadian coal is used. At the end of the year there were in Nova Scotia 670 ovens in operation, 64 idle and 120 building. In Alberta 226 were in operation and 40 idle, and in British Columbia 767 in operation and 753 idle. The ovens of the Dominion Iron and Steel Company are of the Otto Hoffman by-product type and there were recovered as by-products 4,016,824 gal. of tar and 3351 short tons of sulphate of ammonia.

(By E. Jacobs.)—The production of coal and coke in British Columbia in 1909, it seems quite safe to assert, was the largest of any year since coal mining was commenced in this province. About 1,450,000 tons were produced in what is officially known as the Coast coal mining district (Vancouver island about 1,380,000 and Nicola 70,000 tons), and the remaining 1,050,000 tons came from the Crow's Nest district in southeast Kootenay. About 450,000 tons were made into approximately 277,000 tons of coke. The older and larger collieries increased their output, and three or four new collieries produced steadily.

Men from Tacoma, Wash., purchased in August 4800 acres of coal lands in the vicinity of the Dunsmuir Extension colliery. Coal has been found in various parts of the northern country through which the Grand Trunk Pacific railway is being built west of the Rocky mountains to Prince Rupert; the limits of one area discovered on the Morice river in 1908 by W. W. Leach, of the Geological Survey of Canada, were largely determined by that official during the field work season of 1909; another area, near the headwaters of the Skeena river, was examined by Charles Fergie. In the Nicola country, the Nicola Valley Coal and Coke Company did much development work in its Nos. 1 and 5 mines, Middlesboro collieries, and also gave attention to Nos. 2, 3 and 4. The coal opened in No. 5 is exceptionally clean and hard and of excellent quality.

The Crow's Nest Pass Coal Company is the largest coal producer in the Crow's Nest country. It has three collieries—at Carbonado, Coal Creek and Michel, respectively. Its output was from Coal Creek and Michel. About 900,000 tons, gross, of coal were mined, and about 250,000 tons of coke made in 1909. Additions to the power plant in 1909 were the installation of three Rand Corliss air compressors, one at Coal Creek and two at Michel. At the former colliery the machine put in is a compound-condensing steam, four-stage air compressor, having a capacity of 1300 cu.ft. per min. compressed to 1200 lb. A similar machine was installed at Michel, and also a low-pressure, compound, condensing steam and compound air compressor having a capacity of 4523 cu.ft. per min. The latter, which is equipped with aftercooler, condensing apparatus, etc., supplies air for operating pumps, hoisting engines and coal cutters.

China. (By T. T. Read.)—Coal production in China showed a healthy increase during 1909, the working mines increasing their output and some new ones being opened. The chief of these are the Lanchow mines, which are now engaged in a dispute with the Chinese Engineering and Mining Company as to their right to work. The gentry of Chili province have appointed a committee to consider ways and means to recover

ESTIMATED COAL PRODUCTION, CHINA, 1909.

Province.	Anthracite, Tons.	Bituminous, Tons.	Lignite, Tons.
Manchuria	....	....	1,000,000
Chili	840,000	2,090,000	150,000
Shausi	4,000,000	....	....
Sheusi	....	500,000	....
Kausu	....	500,000	....
Shantung	300,000	500,000	....
Houan	1,000,000	....	....
Ssuchuan	....	500,000	....
Yunuan	....	300,000	....
Chekraieg	....	10,000	....
Kiangsi	....	700,000	....
Hunan	....	200,000	....
Kuangtung	....	50,000	....
Kuanqsi	....	100,000	....
Other provinces	....	100,000	....
Total	6,140,000	5,550,000	1,150,000

from this company the concession under which it operates. There is also a movement on foot to buy back the German mines in Shantung, but this is opposed by the people of the province, as they claim that the mines are now being worked at a loss. The stock of the Peking Syndicate rose greatly during the year, due to exchange operations. The Pao Chin Mining Company makes little progress with its operations in Shansi. The Fushun mines in Manchuria continue their remarkable growth, having nearly doubled their output during 1909. Numerous projects continue to be started to open up additional mines, but these are scarcely needed, the question now being rather to get reasonable freight rates on the coals that are situated at any distance from the ports.

(By E. Walch.)—Among the most important coal mines in China are those of Kaiping at about 150 km. north from Tientsin. They are worked by the Chinese Engineering and Mining Company, Ltd., consisting mainly of French and Belgian capital. The company sank three pits called Tongsham, Noedwestshaft and Linsi, having an aggregate output of 1,200,000 tons in 1908. The market is mainly on the spot, coal being used for the North China railway, or sold in Tonku, Tientsin or Peking. A small part, 187,000 tons in 1907, was exported from Chingwantao to the northern and southern markets. The retail prices quoted at Tientsin range from $8.90 for household coal to $11.50 for double-screened large steam coal; fines are quoted $6.40 to $6.90 and coke from $12 to $18 (Chinese dollars). In the same district are many Chinese enterprises, among which may be mentioned the Peayang Lanchow Mining Company, working a mine at Shen Cha Lin and producing 100 to 150 tons of poor coal per day. Outside of the Kaiping enterprise, the most important coal mine in China is that of Lincheng, worked by a Belgian-Chinese company, floated by the Société Anonyme des Mines du Luhan, head office of which is in Brussels. The mines are 350 km. from Peking and 890 km. from Hankow, on the Peking-Hankow railroad. The product is long flame coal. At its start, in 1905, the company resumed the Chinese workings. Now its first modern plant is almost completed and fitted with the most up-to-date appliances. It includes two shafts, 12 ft. in diameter, one of which is equipped for an output of 2000 tons per day, with a screening plant for 1000 tons in 10 hours. The plant includes air drills, steam underground pumps, electric lights, fans, lamp shop, storehouse, repair shops with foundry, etc., and eight boilers. The colliery is connected with the Peking-Hankow system. Its principal consumer will be the Peking-Hankow railway, and brick manufactories along the line. Its competitors are the Ting Cheou mine at 250 km. from Peking, the Feng Lo Tcheng mine at

492 km. from Peking, both Chinese enterprises, and the Peking Syndicate, which works an anthracite coal vein at Wei Huoi Fou, 589 km. from Peking. The Lincheng mines are under the management of a Belgian mining engineer. Another mining district of future importance is known as the Shansi district. The coal seams surround the Chen-Kia-Choang to Tayuenfou railroad, a branch of the Peking-Hankow system. The only mines worked by modern contrivances are those of Ching-Ching at 13 km. from the railroad, to which they are connected by a narrow-gage track. These mines belong to a German syndicate, which obtained from the Imperial Government a contract made under the same conditions as that of the Société des Mines du Luhan. The capital is 500,000 taels, viz., $300,000 (U. S.). The daily output is 450 to 500 tons. Coal is sold to the Peking-Hankow railway and also in Tientsin. A great number of local exploitations are found all along the line. For example, about 300,000 ℔. of coal are produced daily at Cheou-Iang-Hien and sold at the mine at ½ to 1½ samèques per pound, but the cost of transport to the railway station of Iang-Tsuen, together with the taxes charged on coal transported, bring the price up to about $2 (Chinese) per metric ton, delivered, Lang-Tsuen. The cost price of the same ton at Tientsin is $10.50 (Chinese), due to the railway tariff and various duties. In the north is found another important center at Shangtung, producing two qualities, that of Fangtze and that of Hungshan, with a daily output of 100 tons for the former and 300 tons for the latter, which is mainly sold to the German warships. Selling prices are: Fangtze (Chinese dollars) $8.50 to $9; Hungshan, 27 shillings. In Manchuria, coal is found on the eastern part of the mountains along the Liao valley. The Japanese work now the mines of Fushan, Yentai and Penh-sihu with an increasing output, which was over 1000 tons per day in September, 1908. The development of coal mining in China is therefore considerable. The local industries are scarce. The consumers are the railways and individuals for household consumption. The demand is increasing steadily.

Mexico.—The bituminous coalfield in Coahuila, in which nearly all of the operating coal mines are, is 50x40 miles in extent. The coal series consist of shale and sandstone. There are usually two seams of coal, the upper thinner and from 1 to 4 ft. thick, while the lower is from 4 to 10 ft. thick. The present output of this coalfield is about 3500 tons daily; the yearly consumption of coal in Mexico is about 4,500,000 tons, and that of coke is about one-fourth of the coal consumption. The coke output is about one-eighth of the consumption, the deficiency in coal and coke coming from the United States and Europe. There is another coalfield in northern Mexico, near the boundary, producing lignite, the demand for which is limited at present. Other coal deposits are in Sonora, Puebla, Oaxaca, Veracruz and Jalisco, but none of them are being commercially exploited at this time.

The reports of the mining companies in Mexico show that a total of 919,338 metric tons of coal was produced in 1909. It is estimated that this production will be largely increased in 1910. Practically all of the mines are situated in the State of Coahuila, although there are said to be extensive undeveloped coalfields in other parts of the Republic. The coal produced in the Coahuila field is of the coking grade, and during 1909 a total of 150,000 tons of coke was made. Three companies are now building the new type of retort oven, which will make coke in 48 hours, against 72 hours required by the older process. It is announced that the Mexican Coal and Coke Company, an American concern, will soon have 50 of these ovens in operation. The Lampacitos Coal Company is erecting 30 of the ovens, and the Rosita Coal Company will soon have 60 of them. In the Cleote district a battery of 60 beehive ovens was finished in October, and a secondary plant of 60 more ovens is now being installed. It is claimed that at the present rate of development of the coal industry in Mexico, it will be only a few more years when it will be unnecessary to import coal from the United States.

(By H. Brendel.)—Mexico consumes about 4,500,000 tons of coal and about 2,000,000 tons of coke per annum. As the total coal output of the Republic is less than 1,000,000 tons each year, the consumers are dependent on the United States and Europe for the remainder of their fuel supply. Up to the present time there are no import duties on coal and coke brought into Mexico; however, the coal-mining companies in Mexico representing a large capitalization, are urging the government to impose a duty on coal and coke. The railroads have recently advanced the freight rate on these commodities imported through El Paso, Eagle Pass, Laredo, Tampico and Vera Cruz, $1 per ton, allowing the old rate on domestic coal to remain. As Mexico imported about 3,000,000 tons of coal and 1,500,000 tons of coke last year, this will either mean added revenue to the railroads of approximately $4,500,000, or else an increase in the price of domestic coal. The production of coke in Mexico will soon become an important industry, as the Mexican coal is well adapted for making excellent coke. So far there are only about 400 ovens operating in the Republic; the beehive style of oven is used exclusively.

Mine timber in Mexico sells for a high price, as most of it has to be imported from Texas. This timber expense, however, is largely offset by the cheap labor; another additional advantage is that there are no strikes instigated by labor agitators. The government does not look with favor upon unionism, and although the Mexican mining laws are becoming more stringent each year, they show more favor to the operators in cases where injuries and deaths occur through accidents than is shown in the United States. The average cost of mining coal in Mexico, including royalty, timbering, wear and tear and depreciation of plant, surface expenses, etc., until loaded on board cars ready for shipment, averages from 2 to 2.50 pesos ($1 to $1.25 gold) per ton. Good, clean, washed coal in Mexico sells f.o.b. cars at the mines from 6 to 6.50 pesos ($3 to $3.25 gold) per ton. Coke sells from 15 to 17 pesos ($7.50 to $8.50 gold) per ton f.o.b. cars at the mines. From the foregoing figures it is easy to estimate the possible profit attending coal mining in Mexico. Figuring on a 4-ft. seam of coal, good authorities state that such a bed will produce 4000 tons per acre. Drill holes put down in many parts of the Mexican coalfield have shown that some of the seams run more than 4 ft. in thickness.

The Coal Markets in 1909.

The general coal trade in the United States showed an increase of from 10 to 15 per cent. in 1909. The anthracite markets were less affected by the business depression of 1908, and in a reverse manner did not show improvement with the bituminous trade in 1909. As anthracite coal is being used less and less for steam and manufacturing

SHIPMENTS OF ANTHRACITE.
(Tons of 2000 lb.)

	1907		1908		1909	
	Tons.	Per ct.	Tons.	Per ct.	Tons.	Per ct.
Reading	14,018,795	20.9	12,578,883	19.4	11,920,757	19.2
Lehigh Valley	11,532,255	17.2	10,772,040	16.7	10,296,627	16.6
N. J. Central	8,714,113	13.0	8,495,425	13.2	7,938,370	12.8
Lackawanna	10,237,919	15.2	10,088,697	15.6	9,531,695	15.3
Del. & Hudson	6,562,768	9.8	6,461,666	9.9	6,136,946	9.9
Pennsylvania	6,203,171	9.2	6,019,457	9.3	5,966,543	9.6
Erie	7,151,683	10.7	7,450,175	11.5	7,461,121	12.3
N. Y. Ont. & Western	2,689,089	4.0	2,798,671	4.4	2,717,826	4.3
Del., Susq. & Schuylkill	(a)	....	(a)	....	(a)	....
Total	67,109,393	100.0	64,665,014	100.0	61,969,885	100.0

(a) Shipments included in total of Lehigh Valley Railroad Company.

purposes, the trade is becoming more stable each year. Anthracite shipments for the year showed a decrease of 2,695,129 tons, which falling off compares with a decrease of 2,444,379 tons in 1908. The total decrease in anthracite shipments in 1909 was 4.2 per cent. The Erie was the only company showing an increase in 1909. The largest decrease was on the Reading.

Alabama. (By L. W. Friedman.)—The Alabama coal market suffered severely through two-thirds of the year 1909. If general conditions throughout the country had not improved greatly during the last few months, the report of the Alabama coal industry in 1909 would have been distressingly poor. The great strides made in coal mining from October to the last of the year succeeded in bringing up the production.

The consuming element, the iron blast furnaces, called for a large proportion of the coal that was produced during the year. The commercial trade was very dull, in fact, in some instances, mining companies were willing to sell at practically cost, including the wear and tear on machinery and the depreciation in the prospective coal. It was in October before any appreciable improvement in the coal market conditions was felt. The iron making in this State then had a big impetus and the demand for coke improved wonderfully. A scarcity of miners and mine laborers became noticeable and concerted steps were taken to bring in more laborers. The wages of the men in the mining industry in this State were not inducive to bring forth much exertion, and at all properties, except the mines operated with convict labor, several in number, there was nothing better than half-work during the greater portion of the year. An advance in the wage scale among the miners and mine laborers was allowed on December 1. This acted as an incentive for the men to seek the mining work and to urge those at work already in the industry to give better effort.

The State had but little, if any experience, with organized labor around the coal mines in 1909. Very few companies recognized the union during the year, in fact there was so little given out publicly of the existence of an organization among the coal miners and mine laborers that there is doubt as to whether such an organization is being kept up. Former leaders were heard complaining, occasionally getting into print, but the operations in the mining district did not feel any of the effects and those men who remained in the State were glad to accept any little pittance in the way of work that was offered. When the conditions changed for the better there was great activity at the mines and the production grew as if by magic. The Chief State Mine Inspector, Edward Flynn, and his two assistants, watched the mining operations carefully and issued several warning circulars to the operators and to the mine workers to keep down the fatality list, and at the same time to improve the grade of the coal produced. One hundred and thirty (130) men lost their lives in Alabama mines during 1909.

Coke was a strong commodity practically throughout the year. By autumn the demand became exceedingly strong, and there was talk of importing some of this product to help out. Old coke ovens were put into shape and started up. Improvements were made at coke ovens already in operation. During the depression in 1908 and a great part of 1909, there was quite an accumulation of coke, but, as soon as the consumption of coke started in and went above the output, the stocks began to dwindle. There was some little coke shipped out during the dull period, but this practice was abandoned as the home demand improved. Plans are on foot for the construction of several hundred more coke ovens during 1910. An immense by-product plant has been planned by the Tennessee Coal, Iron and Railroad Company, steam and gases from which will supply a large power plant, which will in turn furnish power for several industries. There were a number of transactions during the year 1909 in coal tracts in Alabama, and development has started in several portions.

Chicago. (By E. Morrison.)—Considered as a whole, the year 1909 was much more satisfactory to coal dealers in Chicago than the previous year, and in its latter half conditions grew steadily better, making the outlook at the end promising for prosperity in the coming year. Illinois and Indiana coals, the chief source of supply for Chicago's wholesale trade, sold at about the same prices as in 1908. These prices were low, permitting only a small margin of profit; on screenings, a size largely used, they were lower for a good part of the year, than in 1908. Competition is keen on these coals; their field of production is large and new mines are coming into existence constantly; so prices have reached a low level at which they seem bound to stay until some sweeping change comes over the coal-producing or the coal-consuming industries.

Opening with a fair sale for domestic coals, because of the weather, 1909 showed in its first half depression for steam coals of all kinds and sizes. Shipments had been largely curtailed to this market in the closing months of 1908, but this condition did not continue to the extent of reducing receipts to the market's consuming capacity. Every few weeks some impatient operator or operators consigned to Chicago enough coal to make a cut in prices that sometimes was so low as to leave no profit. Strict enforcement of demurrage rules by the railroads caused such sales on almost all kinds of coal at different times in the year; yet the market was free from such demoralization as occurreed in some previous years, from general over-shipments.

Early in 1909 Illinois and Indiana screenings were unusually strong because of their use as a substitute for more expensive coals. By September, however, they became very weak and in the latter part of 1909 sold for lower prices than at any time in 1908. In proportion, lump grew strong. Very low prices prevailed on lump during the summer months, but after August it gained steadily in strength. Run-of-mine from Western mines held a medium course between lump and screenings. With the increasing use of automatic stokers, fine coals become more and more in demand in the Chicago market, aside from the months of mild weather when they were naturally popular with steam users. Sales of coal for harvesting use were probably greater than ever before. This demand, coming in the summer and early autumn, was marked by a preference for high-grade coals on the part of harvesters, and it was accompanied by the general revival of manufacturing and general business, making the summer an unusually busy season for coal dealers.

Average prices, for car lots of Illinois and Indiana coals (which constitute two-thirds or more of the total supply sold in the Chicago market), are given in the accompanying table.

PRICES OF WESTERN COALS AT CHICAGO IN 1909.

Month.	Lump and Egg.	Run-of-Mine.	Screenings.
Jan.	$1.85@$2.65	$1.61@$1.75	$1.30@$1.60
Feb.	1.75@ 2.50	1.60@ 1.75	1.30@ 1.60
Mar.	1.75@ 2.50	1.60@ 1.75	1.30@ 1.60
Apr.	1.75@ 2.30	1.60@ 1.75	1.40@ 1.60
May	1.75@ 2.25	1.60@ 1.75	1.40@ 1.70
June	1 75@ 2.25	1.60@ 1.75	1.40@ 1.70
July	1.75@ 2.25	1.60@ 1.75	1.50@ 1.75
Aug.	1.75@ 2.35	1.60@ 1.75	1.30@ 1.65
Sept.	1 75@ 2.40	1.60@ 1.75	1.20@ 1.45
Oct.	1.75@ 2.50	1.65@ 1.75	1.00@ 1.30
Nov.	2.00@ 3.00	1.75@ 1.85	0.95@ 1.15
Dec.	2.00@ 3.00	1.75@ 1.85	0.95@ 1.15

Eastern bituminous coals gained with the revival of business and smokeless especially found increased favor, though for the greater part of the year it was in over-supply and sold at discounts from the circular prices. Pocahontas and New River brought $3.15@3.80 for lump and egg, and $2.85@3.15 for run-of-mine, the lowest prices being received in the summer. These quotations represent $2.05 over prices at the mines, that being the freight rate to Chicago. Hocking Valley coal throughout the spring and summer was too plentiful for maintenance of the circular price of $3.15, and at times sold for 40c. less than that price. This coal was in good demand throughout 1909, especially in the last quarter, when shipments of it were well regulated to the demand and the circular price was generally adhered to. Youghiogheny, the leading gas coal, sold at $3.15 steadily and figured almost wholly in contract sales. Contracts for supplies of steam coal, of all grades, were made in the spring months of 1909 to a greater extent, probably, than ever before, but at low prices. Anthracite sold to about its usual amount throughout 1909, at the same prices as in 1908, and the market for it was not marked by any extraordinary features except that an unusual amount of free coal was sold at an average of 25c. under established prices, in the summer and autumn months. All sizes were in good supply throughout the year; in November and December the demand for nut was so large as to make its prompt movement occasionally difficult.

Pittsburg. (By B. E. V. Luty.)—Coal production in the Pittsburg district in 1909 showed a slight gain over 1908, but fell far short of the output in 1907, the record year. Prices, except toward the close of the year, averaged a trifle below those of 1908, but on account of the greater regularity of operations the results of 1909 were on the whole more satisfactory than those of 1908. Prices were almost stationary during the first nine months of 1909, averaging on the basis of $1.05 for mine-run. In October, toward the close of the lake shipping season, coal became somewhat scarce and prices took a jump to $1.15@1.25, and during the closing three months of the year the average price was fully $1.15 for mine-run.

The production of the Pittsburg Coal Company, the leading interest, compares as follows: First nine months, 1907, 13,302,634 tons; first nine months, 1908, 9,726,387; first nine months, 1909, 9,718334. There was a decrease of 8053 tons from 1908 to 1909, but the output in the three closing months of 1909 ran well ahead of the output in the corresponding period of 1908, indicating a total for the year of about 14,000,000 tons, against 13,217,545 tons in 1908.

The total output of the Monongahela River Consolidated Coal and Coke Company, the leading river shipper, was about 6,500,000 tons. Of this total about 2,000,000 tons was shipped south by water, about 2,000,000 tons was shipped by rail and the remainder, considerably in excess of 2,000,000 tons, was shipped by water to consumers in this industrial district. The company's production for its fiscal year ended October 31 was as follows: Pittsburg district, 5,985,486 tons in 1908, as compared with 5,947,826 tons in 1909. The Ohio Valley Coal and Mining Company, a subsidiary operating in Kentucky, produced 110,624 tons in 1908, and 84,566 tons in 1909. The total production of the Monongahela Consolidated in 1908 was 6.096,110 tons, which compares with an output of 6,032,392 tons in 1909.

The river shipping season was unusually short, as it did not open until Jan. 10 of the year, extending to the middle of June, a trifle over five months. During this period there were short spells of low water, not long enough to interfere with steady mining operations. After the close of the regular season there was but one rise, in September, giving only a barge stage upon which about 100,000 tons could be shipped. The lake coal trade reached a greater tonnage than in 1908, but fell far short of 1907. The season was late in opening, although not as late as in 1908. No serious labor questions arose in the year as a two-year agreement had been signed in 1908 with the United Mine Workers of America, to run through March 31, 1910. In July some friction arose over the kind of explosives to be used, and for a short time a strike was threatened, but such trouble was averted. The railroad-car supply was fairly adequate throughout the year, although the usual difficulties were experienced toward the close of lake navigation. On account of the increase in industrial operations a severe car shortage was expected for November and December, but the unusually good weather averted serious trouble.

The production of coke in the Connellsville and lower Connellsville regions may be estimated as below, compared with an estimate for 1908 and the Geological Survey's figures for the three preceding years: In 1905, 15,236,387 short tons; 1906, 17,245,975; 1907, 19,400,327; 1908, 10,700,000 and 1909, 17,800,000 tons. Coke production in the Connellsville and adjacent fields naturally followed the course of pig-iron production in the central West. The year opened with increasing production all along the line, but a backset occurred in March and April, after which there was a steady gain until the two closing months of 1909, during which production was practically stationary.

Prices of coke in 1909 showed the most spectacular movement in the history of the industry. Late in 1908 contracts for Connellsville furnace coke were made at $1.90, and later at $2, for both the first half of 1909 and for the entire year, the majority of furnaces making contracts. Pig iron declined steadily in the early months and by April reached a point which induced many furnaces, having $1.90 and $2 contracts, to insist that they would have to have a readjustment of the contract prices or go out of blast. In a number of cases the coke producers consented to a readjustment, the new price generally being $1.60@1.70. In the case of half-year contracts the operators generally insisted upon a contract being signed for the second half at the new price, as a condition of the readjustment. Straight sales for the second half were also made at from $1.60@1.70. Thus the opening of 1909 saw furnace-coke contracts in force at $1.90 and $2, the middle of the year contracts at $1.60 and $1.70. Then the market turned and a tremendous advance occurred: in August a few far-sighted furnacemen made contracts for 1910 at higher than $2, and in September others contracted at $2.90; in the case of two or three, small tonnages of high grade coke were contracted for at $3 for the whole of 1910. It has been but rarely that prices approaching $3 have been obtained on contracts for furnace coke, and then only as the culmination of a protracted rise extending over a series of years. The strongest period was in September and early October, the market softening slightly thereafter until at the close of 1909 it was easily possible to place contracts for 1910 at $2.75 and probably at less. Early in January, 1910, two contracts were made at $2.50.

MONTHLY AVERAGE PRICES FOR CONNELLSVILLE COKE.
(Per 2000 lb. at ovens.)

Month	Furnace.	Foundry.	Month.	Furnace.	Foundry.
January	$1.70	$2.10	July	$1.55	$1.85
February	1.65	2.00	August	1.75	2.00
March	1.55	2.00	September	2.30	2.50
April	1.43	1.90	October	2.80	2.75
May	1.45	1.85	November	2.85	3.00
June	1.50	1.85	December	2.70	3.10

An illustration of the vagaries of the market was given through the contract made in May between the Thompson-Connellsville Coke Company and the Jones & Laughlin Steel Company, covering 30,000 tons of furnace coke monthly for a period of three years, shipments to begin nominally September 1, or upon the completion of the steel company's three new blast furnaces at Aliquippa. The price was $2, the steel company at the same time agreeing to help the coke company finance the erection of the 400 new ovens required to supply the tonnage. When the news of the contract came out it was received with incredulity in many quarters, it being urged that no large consumer would agree to pay so high a price, but it was merely a case of the steel company being wiser than its critics since at $2.75 for 1910 coke, the price for two following years could be down to $1.62½ and still make the $2 average for the three years.

In the latter part of March, there was launched the ambitious project of consolidating all the coke operations of the Connellsville and lower Connellsville region with the exception of the H. C. Frick Coke Company and some of the independent steel and blast-furnace interests. The real parties back of the movement were never completely identified, their representative being John W. Boileau, of Pittsburg. Letters were mailed March 19 to all the independent coke operators asking for options on their properties good until October 1. The options were given, although usually at very high prices, much of the coal in the old basin and in the lower district being priced in the neighborhood of $5000 an acre. On June 20, all the options expected having been received, appraisements commenced. It had been given out that the operations would be purchased on a cash basis, but that some of the higher-priced options would have to be scaled down. The appraisements were very thorough, and altogether a large amount of money was spent by the promoters, but the final outcome was a complete failure. Practically none of the options were revised. Instead of the cash basis at first promised, the promoters proposed that the sellers should take stock in the new company, except for a modicum of cash which in most cases would have been insufficient to clear the properties of bonded and floating indebtedness.

When the enthusiasm of the promoters was at its hight the statement was made that the history of the Connellsville coke merger would be made the subject of an exhaustive magazine article, so novel were the principles involved and so skillfully was the work being done; but the outcome of the deal was not as was expected, and it remains that the identity of the principals has not been definitely disclosed, and that the causes prompting the effort and the reasons of the failure are matters purely for speculation. Perhaps the most adequate explanation of why the Connellsville coke properties could not be merged can be found in the one thing of all which time and place change least—human nature. The Connellsville coke operators were ready cheerfully to take their chances for the future, large profits or small profits as time should develop, but to change their hopes into present realization required the offering of the maximum of the possibilities in the form of cash or negotiable securities of guaranteed value, and to do that no capitalists could undertake. The irony of the failure was brought out in the antithesis that in May the critics of the proposition found their *reductio ad absurdum* in the computation that the new company, to make adequate returns on its capitalization, would have to obtain an average of $2 a ton for its coke—a thing apparently not to be thought of in the then temper of the market—whereas before those options expired, October 1, furnace coke on 1910 contracts, made in competition in the open market, carried prices well in excess of $2.75.

It is understood to have been definitely decided in the year by the United States Steel Corporation that it will erect in the Connellsville region no more coke ovens, neither the beehive now used nor by-product, except possibly to round out some plants already in operation, and that future expansion with Connellsville coking coal will be with by-product ovens at the point of consumption. The first operation will probably be in the Youngstown district. The advantages of by-product coking have been patent to students of the subject for years, and need not be referred to here. It may be noted, however, as germane to this review, that the H. C. Frick Coke Company is at the present time shipping

Connellsville coal from some of its operations to other properties in the region at which the coal is worked out, and paying the railroads something at least for the service, whereas the freight on coke from the Connellsville region to Youngstown, paid regularly on the large shipments being made, is $1.30, while the coal rate is 90 cents, so that at 75 per cent., the yield expected from Connellsville coal in by-product ovens, against its yield of 66⅔ per cent. obtained in beehive ovens, the freight on the coal required to make a ton of coke would be $1.20, a saving of 10c. per ton of coke in the mere matter of transportation.

The Seaboard Coal Trade.

The Seaboard coal trade in 1909 was, on the whole, a disappointment. There was not the active recovery from the depression of the previous year which had been expected. The consumption was of course large, but there was not a demand strong enough to overcome the tendency to oversupply which always exists.

Anthracite.—The anthracite trade varies less as a rule than any other. For what are known as the domestic sizes there is a steady demand as a necessity of life throughout the East. This is affected a little by the accident of a severe or mild winter, but not to any great extent. For the small or steam sizes, demand is affected more by the condition of business than that for the domestic sizes, but a large part of this coal is consumed by the public utilities, such as lighting plants, electric carline plants and the like, whose consumption is not much varied by the state of trade.

The market in 1909 presented one unusual feature, in that it was not in the least affected by talk of strike or suspension. The mining agreement in the anthracite region expired April 1, but it was generally known that the companies had made provision for possible trouble by accumulating heavy stocks. Their position was strong. There was no suspension of mining, though the discussions over the agreement dragged out for six weeks. Matters were finally settled by extending for three years the contract which has been in force ever since it was formulated by the Strike Commission of 1903, and which has now stood the test of seven years.

Throughout the year the schedule prices of prepared or domestic sizes at tidewater were unchanged, except for the summer discounts, at $4.75 for broken and $5 for egg, stove and chestnut, all per long ton, tidewater terminal points. The discounts from these prices were 50c. in April, 40c. in May, 30c. in June, 20c. in July and 10c. in August; returning to the fall schedule on September 1. For the small or steam sizes a fair average for the year is $3.10 to $3.25 for pea; $2.25 to $2.50 for buckwheat; $1.75 to $2 for No. 2 buckwheat or rice; $1.35 to $1.50 for barley. These prices are f.o.b. tidewater points, according to quality, and a large part of this steam coal is sold and delivered on yearly contracts, so that fluctuations only affect about one-fourth of the sales.

Bituminous.—Trade was disturbed along the Seaboard and in New England territory all through the year by the competition of West Virginia coal. Good Pocahontas and New River coal in large quantities was offered and placed at about $2.15 per ton, f.o.b., Lambert's Point and Newport News. In some cases, in New England, contracts were made at delivered prices, a practice not usual in the trade. The effect of these sales on Central Pennsylvania and Maryland operators will be realized when it is stated that tidewater prices on contract and current business for a large part of the year were equivalent to 90c. to $1 at the mine for good steam coal, and varying up to $1.50 only for a few high-grade coals, while gas coal realized 55c. to 65c. for slack, and 65c. to 70c. for run-of-mine at the mines.

This West Virginia competition did not affect so much the inland trade whch is supplied directly by rail. That trade was generally better throughout the year than the immediate seaboard trade.

From August to October there was much complaint of a shortage of cars, and at times there was difficulty in making deliveries of coal as promptly as it was needed.

One feature of the coal trade in 1909, which is hardly yet fully understood or appreciated outside, was the increased disposition of large consumers to deal directly with producers wherever possible. This is steadily increasing and may in time—possibly a short time—lead to the practical elimination from the trade of the commission houses which have held so large a place in the past.

Coastwise Shipments.—A large quantity of coal is carried from the tidewater terminals of the coal roads to eastern points by water. Steam

COASTWISE COAL SHIPMENTS.
(In tons of 2240 lb.).

	1908.			1909.		
	Anthracite.	Bituminous.	Total.	Anthracite.	Bituminous.	Total.
New York (*a*)	15,069,981	10,247,014	25,316,995	14,418,292	10,549,974	24,968,266
Philadelphia	2,164,747	4,675,767	6,840,514	2,001,866	4,674,276	6,676,142
Baltimore	251,739	3,704,851	3,956,590	235,233	3,344,225	3,579,458
Newport News	....	2,742,294	2,742,294	....	3,495,596	3,495,596
Norfolk	....	1,651,093	1,651,093	....	2,047,417	2,047,417
Total	17,486,467	23,021,019	40,507,486	16,655,391	24,111,488	40,766,879

(*a*) New York includes all the New York harbor shipping ports.

colliers are making some incursions into this trade, especially with West Virginia coal. Other bituminous trade is carried largely by the sailing vessels, but the greater part of the anthracite is now carried by the barges owned by the coal companies.

On the whole the year was a poor one in this trade, owing to the general oversupply of boats and the competition for charters. A part of the depression is due to the diversion to the Poughkeepsie Bridge line of a considerable trade which formerly went by way of the ports on Long Island Sound.

In the case of the New York shipments a large part—roughly, between 60 and 70 per cent.—consists of barge traffic carried to the New York City and neighboring wharves.

Recent Practice in Coal Mining.

Following in line with the work of the previous year, the matter of coal mine accidents, their cause and prevention, has been the all-important subject of discussion in recent months. It is true that the opinions of many of our most experienced engineers still differ widely in their views; however, no one will doubt that gradual progress toward betterment is being accomplished. Excluding Alaska, and subtracting the 10,658,000,000 tons of coal already mined, we have remaining, in the United States, about 2100 billion tons of coal. The area of our present accessible coalfields is about 330,000 square miles. The Federal Government's recently adopted conservation policy has brought about a material change in the value of the public coal lands. Until a few years ago, all public coal lands were valued uniformly at a rate of $10 or $20 an acre, according if they lie less or more than 15 miles from a railroad. The present value fixed for the Government coal lands, under the new system, is 100 million dollars more than the value at which they were formerly appraised.

Labor.—During 1909 there was more of a tendency to enforce the laws we already have, rather than pass new legislation. In many States, the law requires that each man shall have served an apprenticeship in the mines before he is eligible to work as a miner. It was shown recently that certificates of competency were issued to many persons who were not entitled to them. This evil has been largely corrected. One form of legislation that must come soon is the establishment of a relief tax to create a fund to aid the unfortunate widows and children left helpless by coal-mine accidents. One good suggestion is that each State levy a tax of $\frac{3}{4}$c. per ton on all coal mined, or produced for the manufacture of coke. In Pennsylvania alone, coal-mine accidents leave 574 widows and 1316 orphans each year. The additional cost of production entailed by such a tax would have to be paid by the consumer. The person who consumes 10 tons of coal in a year would have an additional expense of about $7\frac{1}{2}$ cents.

Surface Equipment.—The surface equipment of a modern mine should include a water softening and cooling plant, and in many cases a briquet plant. The first consideration in building a mining plant is to decide whether the construction shall be of wood or shall be fireproof. After this point has been settled, it is then necessary to decide whether greater consideration shall be given to the first cost of the plant or to the cost of maintenance and operation. The most important point favoring fireproof construction is that such a policy insures the operator against the loss incurred through the closing down of his plant after the tipple has been destroyed by fire. Many tipples are now being equipped with rotary dumps, so as to avoid the use of a door on the car. This gives a solid box-car and helps prevent the distribution of dust in the mine. The rotary dump also simplifies the arrangement of the track at the point of dumping.

Although there is a divergence of opinion as to the advisability of providing a wash house near the mouth of coal mines for the use of employees, the more modern mines are now being equipped with such baths. At one large colliery in Scotland, where 1100 men are employed, an elaborate system of baths has been installed. At this mine, all of the workingmen who desire to avail themselves of the baths pay 2c. per week toward their maintenance. This sum is barely half of the cost of providing the baths. The aerial wire-rope tramway is one feature that is being used more extensively around coal mines. In some instances, these tramways are used to carry away ashes and refuse, but, in most cases, such installations are used to transport coal from mines difficult of access to tipples or dumping stations alongside the railway. One such tramway in Europe is seven miles long and has spans 3660 ft. in length. The buckets on this tramway have a capacity of 1300 lb. and are spaced 210 ft. apart. The speed of the moving cable is 500 ft. per minute, and the buckets are attached to it by a friction grip. Before this tramway was erected, the cost of transportation was 29c. per ton; at the present time the cost is only 6c. per ton.

Power Stations.—There is a tendency on the part of all large companies at present to provide one central power station for a group of collieries. Compressed air is being adopted as the motive power by a number of companies that operate gaseous mines. Where electricity is used, the three-phase alternating current is preferable to the continuous current, on account of the danger that lies in the commutator. Continuous-current motors generally spark at the brushes. The cost of electric power depends largely on the size of the plant. In one instance where a large central plant is used, the output was 2500 kw., the cost per kilowatt being $268. The total cost of this plant was $700,000. At another station having an output of 40,000 kw., and costing $5,800,000, the total cost per kilowatt was only $139.

Much care should be exercised in the selection of cables for the transmission of current. Sixteen insulated and armored cables, each carrying 100 e.h.p. will be much more expensive than four cables each carrying 400 e.h.p. If we transmit current two miles, with 400 volts at the motor, on a drop of 10 per cent. per mile from generator to motor, the cost incurred when 16 cables are used will be at least 20 per cent. greater than if all the power were taken two miles in four large cables. In deciding such a problem, it is necessary to reconcile two conflicting needs: First, the convenience and safety of low-tension motors; second, the economy of high tension mains. One point in the transmission of current that is worthy of remembering is that the cost of copper varies inversely as the square of the voltage. Steam turbines as prime movers are most desirable. These turbines should be run condensing.

Hoisting.—The most important advances made in the practice of hoisting are along the lines of electrical hoisting. Some of the advantages of electrical winding are the greater flexibility and the uniform torque of the electrical motor, which reduces the flywheel effect of the winding engine to the minimum amount. The steam engine must, in many cases, have a greater flywheel effect because of its reciprocating action. Electric hoists insure less time per wind with the same maximum speed, which results in an increased carrying capacity of the shaft. Another important advantage is the saving in steam. Some engineers claim that the greatest advantage of electrical winding lies in the ease and certainty of control. Electrical winding is perfectly safe and reliable, but it is somewhat expensive in its first cost. Practically all of the new mines of importance on the continent are equipped with electrical winding plants. The English and Americans have been slower to adopt this system. The owner of a colliery that is equipped with modern steam-winding engines cannot be expected to discard such a valuable plant, but in the case of new mines, especiallly where electricity is to be used for other purposes, it seems advisable for coal companies to adopt electrical hoisting.

Circular Shafts.—American mines again differ from European mines in having rectangular shafts, while the foreign operators seem to prefer circular shafts. The advocates of circular shafts claim that removing the corners in rectangular excavations is expensive and that there is also more danger to the workmen from the pressure. A circular shaft 20 ft. in diameter would be equivalent to a rectangular shaft 12x20 ft. it is evident, therefore, assuming the same hoisting capacity in either form of shaft, that the excess area, which makes ventilation possible, would be the same in either a circular or a rectangular shaft. European engineers claim that the cost of lining is as 5 : 9 in favor of circular shafts, also that where great pressure is encountered the circular form is the only safe one. For a given area, a circular shaft presents less rubbing surface, or resistance, to the passage of the ventilating current. The principal arguments advanced favoring the circular form are that less material needs to be removed for a given cage space, and that in sinking, the permanent lining is at once put in place as the work progresses. Although it costs more to line a circular shaft, the upkeep and repairs on such a shaft are less than on the rectangular style. All things considered, American engineers would do well to consider the advisability of sinking circular shafts in preference to rectangular ones.

Ventilation.—One engineer has well said, "It is quality rather than quantity that is needed in ventilating coal mines." There may be plenty of air passing through the main entry of a mine, and still a lack of ventilation at the faces where the miners are working. This condition is generally due to poorly constructed stoppings. Practically all large companies are now building their stoppings substantially of brick or stone. For minor stoppings or brattices, a good mixture of mortar can be made by taking one part of cement to about seven parts of fine coal dust. All mines should equip with fans that can be reversed on short notice. In certain Canadian mines, the fans are run one way in summer and the reverse in winter.

In ordinary ventilation, more than 50 per cent. of the energy developed is often expended in overcoming friction. If friction were entirely absent, a difference of pressure equal to a water column $\frac{1}{4}$ in. high would be sufficient to produce a movement in the air current equal to more than 2000 ft. per minute. Much attention should be devoted to the elimination of friction. Ascentional ventilation should be adopted to aid the fans wherever possible. It is generally advisable to conduct the fresh air to the lowest point in the mine and finish at the highest. One of the disadvantages of sprinkling is that the more vapor there is in the air, the greater the strain on the fans. A waterfall in an upcast shaft greatly retards ventilation. The ventilation of a mine should be maintained even when the pit is not working. Our laws should specify that ventilation shall be maintained at all times unless a mine is abandoned.

Haulage.—Electrical haulage is being adopted at practically all mines where the underground conditions are not too gaseous. Engineers no longer dispute that where conditions are favorable electrical haulage is the cheapest. The endless-rope system of haulage remains in favor at many collieries where special conditions exist. The best features of this system are: (1) It is capable of dealing with large outputs in an easy form; (2) there is less wear and tear of rolling stock than with other systems; (3) it travels at a much lower speed than any other system for a given output; and (4) it is, as a result of the foregoing advantages, less liable to breakage and accidents to persons and animals. Where main-rope haulage is used, it is impossible to fix any definite gradient upon which the cars will run back by gravity. The degree of slope upon which a train of cars will self-act depends largely upon the weight of the car, the size of the wheels, the condition of the road, and the weight of the rails. It will generally be found that a gradient of 2 in 26 is a fair allowance.

Machine Mining.—One mining machine with three attendants will generally do as much work as 20 men can accomplish by hand labor. This saving in time, labor and cost has made mining machines indispensable. Every coal-producing State in the Union will eventually enforce laws prohibiting shooting coal from the solid. A machine using a cutter chain traveling horizontally across the face of the coal has the largest capacity and consumes the least amount of power. This style of coal cutter is most commonly used in America and is generally driven by an electric motor. Where a mine has a rolling bottom or where a band of sulphur occurs near the bottom of the seam, many chain-breast machines will not work satisfactorily. In such mines, coal-punching machines are most often employed. The puncher machine is also especially adaptable in coal where the cleats are not well defined, as it allows a condition of shooting which places the coal in such a shape that it is easily loaded. Coal always rolls better when shot after being undercut with a puncher. Whether to adopt the chain-breast or the puncher machine at any mine is a question that requires careful consideration on the part of the mine superintendent.

As to the saving that results from machine mining, it may be said that at a mine producing 1000 tons per day and having a 15c. margin in favor of machine mining, the gross saving would be about $150 a day, or $30,000 per year of 200 days. In such a case the company can maintain its output with 20 per cent. fewer men than are required when hand mining is employed. The $30,000 saving will pay for the machine plant, installation and cost of maintenance, as well as interest and depreciation, in about one year's time. The advantages of coal cutting are: (1) an increased percentage of large coal; (2) the coal is mined in a firmer and better condition; (3) a more regular line of face is obtained, leading to more systematic timbering; (4) increased safety conditions for the miner; (5) thin seams can be profitably mined; (6) increased output; and (7) fewer explosives are required for getting down the coal. The effectiveness of machine mining is shown by the fact that American coal operators, with fewer men, produce 60 per cent. more coal than is mined in Great Britain.

Mine Explosions.—The greatest problem in coal mining is the prevention of mine explosions, and consequently, the attention of all those connected with the industry has been directed toward this subject. The dangerous factor in mine explosions is either gas or dust, and since good ventilation will prevent explosions due to gas, the chief question to solve is the dust problem. It is now generally understood that coal dust that is fine enough to pass through a 200-mesh sieve can be ignited either by a naked light or the arc of an electric circuit. After careful investigation, the British Royal Commission concluded that, (1) coal dust from many seams is as sensitive to explosion as gunpowder itself; (2) coal dust is sensitive to explosion in proportion to its freedom from impurities; (3) a supply of oxygen, such as is furnished by brisk ventilation makes a coal-dust explosion more probable and more severe; (4) a gas explosion in a fiery mine may be carried on indefinitely by coal dust raised by the explosion itself.

As to the rate at which coal dust is deposited, careful experiments at one mine showed that about 11½ lb. of coal dust were carried in eight hours past the point where the measurements were taken. The velocity of the air carrying this dust was 95 cu.ft. per minute. Other measurements made to determine the quantity of dust deposited on the floor, sides, etc., showed that at the shaft-bottom, where the area of the road was 150 sq.ft., 18 lb. of dust were deposited each working day of 12 hours. At this rate of deposition, it would require about 83 working days to render the road at the bottom of the shaft absolutely dangerous.

Concerning the ignition of coal dust by electric flashes, other experiments have shown that the increase in percentage of ignition is proportional to the increase in current. It is not proportional to the power of the flash, but to the product of this and the voltage. As to the amount of dust that will cause an explosion, one prominent engineer figures that 0.036 lb. of dust per square foot of floor space may be said to represent the explosive capacity of a mine. This engineer says that thorough saturation of the entire intake appears the only method by which every particle of dust, in every section of a mine, can be reached with certainty.

Treating Coal Dust.—In treating dust, some engineers advise moistening the intake air, others advocate direct spraying with water, while others claim that calcium chloride is the solution. There is no question but that in many mines the use of water has a very bad effect on the roof. It should be remembered, however, that it is more often the frequent changes from a wet to a dry condition in the mine that affects the roof rather than the constant application of water. As to calcium chloride, it is a grayish-white substance which has the power of strongly attracting moisture from the atmosphere and of holding same. It contains nothing that is injurious to the miner, roadways, haulage ropes, etc. It does not give off any smell or gas. One mine manager estimates that the cost of sprinkling an entry, 9 ft. wide and 300 ft. long with powdered calcium chloride, would average about $3.12. Water has to be applied daily, whereas calcium chloride will apparently be effective for three months. It may be further stated that the action of calcium chloride liquor upon iron and steel is not one-third as vigorous as the rusting action of plain water. The effect of humidity on the capabilities of miners working underground should not be overlooked by those who introduce moisture into their coal mines.

Shot Firing.—It has been proved recently that about 60 per cent. of all coal-mine explosions have been caused by the careless handling of powder and by blown-out shots. The technologic branch of the United States Geological Survey, realizing the dangers resulting from the use of low-grade flaming explosives, has been making careful tests of all the explosives manufactured for use in coal mines. Certain conditions have been set, and when it is proved that an explosive meets the imposed conditions, such explosive is placed on a permitted list. Some trouble with the miners has followed the attempt to introduce these permitted explosives in many mines. The complaint of the miners has been that the permitted explosives, being high in power and quick of action, make more fine coal and consequently cause them to earn less, when they are paid on a screened-coal basis. Careful experimenting has shown that the production of an added percentage of slack with these high explosives can be largely overcome through their more intelligent use.

The system of firing shots electrically is fast growing in favor. As to the cost of installing a shot-firing system, one company with an output of 1200 tons per day expended $1250 in the installation of a complete shooting plant; of this sum, $850 was for material. The total yearly labor cost of operating this system was approximattely $2000.

As to the cost of firing shots by electricity, taking the average of a number of mines, I find that the cost per ton averages about 1.46c. In mines where shots are fired by using a primary battery, or a good magneto machine, the latter is more reliable, and although it costs more, it is easier to keep it in good order.

Innovations.—A number of new ideas have been applied to coal-mining practice during the past year. At many mines, concrete and steel have been used for mine props. Although the initial cost has been greater when these materials have been used, the results have proved satisfactory for the long pull. The advocates of reinforced concrete props and steel props claim that the life of a timber prop is generally less than two years, and because of this short life 75 per cent. of the cost connected with the use of timber is expended in the labor of setting the prop. Early this year, the hydraulic mining cartridge was introduced into American mines with considerable success. This machine brings the coal down without the use of explosives. Aside from the factor of safety, the advocates of the machine claim that it produces a much larger percentage of lump coal, that it can be used any time during the day or night, reduces the number of roof falls and permits timbering close to the face.

A pneumatic method of transporting coal from underground has been installed and is being tested at mines in southern West Virginia. In the manufacture of coke, great progress has been made toward the introduction of coke-drawing and coke-levelling machines. In the Connellsville field it has been shown that the introduction of such machines has effected a reduction of from 35 to 40 per cent. in the labor costs of producing coke. Much of this saving is offset by items of expense, such as the cost of electric power and repairs on the machines. It is also true that where machines are used more coke is lost in the shape of ashes and breeze. Beehive ovens are being done away with and the general practice is now to build rectangular ovens about 5 ft. wide, with the discharge end 2 in. wider than the pushing end; such ovens are generally 32 ft. long, 7½ ft. high to the bottom of the trunnel head, and 26 to 29 in. between ovens. Among other innovations may be mentioned rescue stations underground and concrete hospitals built underground. In the anthracite field, one inventor has perfected a system for collecting dust in anthracite breakers, thus eliminating a serious difficulty in the treatment of anthracite coal.

Preventive Measures.—In no line of endeavor are preventive measures more necessary than in mining coal. Each superintendent should look ahead and eliminate all the chances possible. The officials of each company should occasionally formulate fire plans by dividing the mine into districts and selecting proper locations for dams. At least 30 ft. of narrow entry is necessary for the location of a substantial dam. A good dam should be built in alternate layers of firebrick, concrete, dirt, and brick and mortar; such a stopping should be from 20 to 30 ft. in length. The oils that miners use, as well as the explosives, should be selected only after careful tests. Not enough attention is given to dangerous top. Miners themselves will generally work under a bad roof if permitted to do so. Nothing is more important than that the miner should make his place safe, and when orders are given to pull down dangerous roof, or to put props under it, the miner who disobeys or delays should be severely punished. It is also true that not enough care is exercised in the selection of fire-bosses. The ability to see a gas cap in a safety lamp is unequal among different men, and consequently the officials responsible for such testing should be required to undergo an examination. Colliery managers themselves may carry on such an examination by having a number of lamps burning in atmospheres of different kinds, and requiring the men to pass by one at a time and state what they can see. This test should be repeated at intervals, especially as the men grow older.

The sanitary conditions in American mines are worse than those existing in the mines of any other important country. The time is fast approaching when American operators will be compelled to take the necessary precautions to combat ankylostomiasis and other diseases that prevail among coal miners. The ankylostoma, or miner's worm, has been for several years the subject of experiments in England, Germany and France. These experiments have shown that the best disinfectant for wet and ill-ventilated mines in sulphate of iron. This costs about $39 a ton. A 1 per cent. solution of it would cover 100,000 sq.yd. of floor 1 cm. deep. This will prevent the development of any eggs. Almost equally effective are cinders. Sea water is a third possible disinfectant; it kills larvæ within an hour. Creosote also kills larvæ quickly. Hence, where the air is moist and there is no danger of fire, the lower end of props should be creosoted to a hight of about half a yard. Ankylostoma larvæ are fond of climbing, and wooden props easily become reservoirs of them. Sanitary closets underground are inexpensive and should be provided at each mine. The stableman or other specially appointed person can attend to these closets.

Conclusions.—There is only one way to figure mine accidents; each fatality must be given a definite cost per ton. Consequently, if we spend in preventive measures a sum equal to the total cost of our accidents, we will not only eliminate such fatalities but will secure greater efficiency from the miners and more satisfaction all around. I do not like to state, but it is true, nevertheless, that precautionary measures are generally greatest where property losses are likely to be greatest. Falls of roof result in more fatalities than any other cause, and have received less attention. We should all value the lives of men more than property. One prominent engineer recently made a wise suggestion, saying that since our coal properties were purchased by the acre rather than by the ton, it would seem advisable to take the acre of coal as the unit of measure of the profitableness of a mining property, instead of taking a ton of coal as the unit of the cost of production and making it the gage of the result.

COPPER.

The production of refined copper in the United States in 1909 was 1,438,751,056 lb. against 1,153,000,000 lb. in 1908, the production of the junk smelters being included. For both years these figures represent the total production of American refineries, which draw supplies of raw material, not only from the United States, Canada and Mexico, but also from other foreign countries. This raw material is partly ore and matte and partly blister copper, the production of Cerro de Pasco being the chief supply of the latter obtained from countries outside of North America.

COPPER STATISTICS OF THE UNITED STATES.
(In pounds.)

	1903	1904	1905	1906	1907	1908	1909
Alaska	(a)	2,043,586	4,703,609	8,700,000	6,610,000	4,394,887	4,057,142
Arizona	153,591,417	191,602,958	222,866,020	263,200,000	256,866,761	290,167,795	292,042,829
California	19,113,861	29,974,154	16,697,486	24,421,000	34,398,823	36,890,353	53,357,451
Colorado	7,809,920	9,401,913	9,854,174	9,565,000	13,344,118	13,896,689	10,487,940
Idaho	(a)	5,422,007	6,500,005	9,493,000	11,471,101	8,749,559	7,770,010
Michigan	192,299,485	208,329,248	218,999,759	224,071,000	220,317,041	222,267,444	227,247,998
Montana	272,555,854	298,314,804	319,179,880	299,850,000	226,290,873	252,558,330	313,838,203
Nevada	(a)	(a)	(a)	426,000	1,462,450	12,174,269	51,835,309
New Mexico	(a)	5,368,666	5,638,843	6,262,000	8,652,873	8,523,652	5,134,506
Utah	38,302,602	47,062,889	51,950,782	49,712,000	68,333,115	70,978,952	100,438,543
Wyoming	(a)	3,565,629	2,393,201	146,000	2,919,137	2,384,356	89,654
Scuthern States	13,855,612	15,211,086	14,907,982	18,821,000	22,408,696	20,822,368	22,837,962
Other States	10,846,477	1,418,065	1,550,000	3,379,000	6,166,098	4,387,836	3,746,895
Total	708,375,228	817,715,005	875,241,741	917,620,000	879,241,766	948,196,490	1,105,336,326

(a) Included in "Other States."

As in previous years, our statistics of domestic production are based upon the Michigan production plus the fine copper content of the blister copper produced by other smelters. These statistics are based upon reports received from all the smelters. As nearly as possible these statistics represent, in our opinion, the production of the mines. The reports received by us from some smelters show copper contents of ore received in excess, or *vice versa,* of the copper contents of blister produced, but our experience has shown it to be impracticable to carry back the statistical investigation of copper production to the mouth of the mine, and consequently, we take the reports of the producers of pig copper as representing most nearly the production of the mines.

Even with the utmost care, and the most enthusiastic coöperation of the smelters, it is impossible to trace all of the copper production accurately to its source of origin. There is some copper included under "other States," that it is impossible to allocate precisely. We believe that the enumeration for 1909 shown in the accompanying table is the closest possible, and very close to the truth, with the possible exception of New Mexico, which territory, we suspect, may be entitled to a larger production than is credited, any increase on its account being at the expense of some other States.

The production of copper originating from scrap and junk, which many of the primary smelters reported, was 12,451,884 lb. in 1909 against 10,000,000 lb. reported by the same concerns in 1908. There is, moreover, a rather large production of copper remelted from scrap and junk by concerns that confine their operations to that business. Their production in 1908 we estimate to have been 25,000,000 lb. Reports that we have received from concerns engaged in this business show 33,348,000 lb. in 1909. Both for 1908 and 1909 the statistics are probably incomplete.

PRODUCTION OF COPPER ACCORDING TO CLASS.
(In pounds.)

Year.	Total Domestic. (*d*)	Total Foreign. (*e*)	Grand Total.	Lake.	Electrolytic.
1897	501,370,295	26,938,254	528,308,549	145,839,749	250,000,000
1898	535,900,232	36,055,352	571,955,584	156,669,098	314,107,776
1899	581,319,091	40,659,868	621,978,959	155,845,786	386,410,356
1900	600,832,505	62,484,290	663,316,795	144,227,340	466,092,663
1901	597,443,212	....	....	155,570,465	(*a*)485,016,400
1902	636,796,381	....	....	170,194,996	(*a*)606,270,500
1903	708,375,228	....	....	192,299,485	(*a*)617,293,600
1904	817,715,005	....	....	208,329,248	705,478,400
1905	875,241,741	183,252,259	1,058,494,000	219,000,000	(*b*)760,000,000
1906	917,620,000	(*c*)247,549,000	(*c*)1,165,169,000	224,071,000	(*b*)865,000,000
1907	879,241,766	(*c*)273,506,124	(*c*)1,152,747,890	220,317,041	854,441,000

(*a*) As estimated by the Metallgesellschaft, Frankfurt am Main. (*b*) Partly estimated. (*c*) Includes copper from domestic scrap and junk. (*d*) Entered the same as production of the mines. (*e*) Difference between the first and third columns.

Year.	Lake.	Electrolytic. (*d*)	Casting. (*d*)	Pig Copper. (*a*)	Total.
1904	208,329,248	705,478,400	(*b*)45,000,000	44,408,000	1,003,215,648
1905	219,000,000	(*c*)760,000,000	46,000,000	33,495,000	(*c*)1,058,494,000
1906	224,071,000	(*c*)860,000,000	52,000,000	29,098,000	(*c*)1,165,169,000
1907	220,317,041	854,441,000	47,957,890	30,032,000	1,152,747,890
1908	222,267,444	850,660,325	44,967,250	35,000,000	1,152,895,019
1909 (*e*)	226,602,134	1,101,518,458	67,471,446	43,159,018	1,438,751,056

(*a*) Exported. (*b*) Estimated. (*c*) Partly estimated. (*d*) Includes copper from scrap and junk. (*e*) The statistics for 1909 are as officially communicated to us by the Copper Producers' Association, except that to its report of 34,123,446 lb. of casting copper we have added 33,348,000 lb. reported to us by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such, regardless of the process by which it is refined.

However, we are safe in saying that the production of remelted copper in 1909 was 45,799,884 lb., against 35,000,000 lb. in 1908. These figures are in addition to the production of virgin copper and are equivalent to about 7 per cent. of the domestic consumption in the respective years.

The domestic deliveries of refined copper, disregarding the deliveries of the junk smelters, during 1909 were 705,051,591 lb. against 488,500,000 in 1908, 538,000,000 in 1907 and 668,600,000 in 1906. Regarding the domestic deliveries in 1909 by quarters, it appears that in the first three months the average was about 48,000,000 lb.; in the second, about 56,-400,000; in the third, about 62,400,000; and in the fourth, 67,700,000. Consumption in 1909 probably did not increase to the amount indicated by the deliveries, inasmuch as manufacturers added to the stocks in their yards toward the end of the year, but there is little doubt that the actual domestic consumption in 1909 was fully 660,000,000 lb.

The statistics show clearly to what extent the American consumption of copper revived in 1909 and dispel the idea expressed during the year that the copper business was lagging behind the industrial improvement in general. Toward the end of 1909 the brass, sheet and tube mills went on over-time in order to keep up with their orders, and business in the lighter sort of wire, such as are required for telephone extensions, was good. It was only for the heavy wire, required for trolley and power transmission purposes, that demand was sluggish, the reason being obviously because the times had not yet become wholly propitious for the financing of new enterprises. The demand for copper in Germany improved materially in 1909, and in France business became fair. It was only in Great Britain that the demand continued sluggish.

During 1909 there was a good deal of complaint respecting the "low price for copper," yet the average for the year was not much below that

EXPORTS OF COPPER FROM THE UNITED STATES. (*a*)
Ore, matte and regulus stated in tons of 2240 lb. Ingots, etc., in pounds.

Country.	1904	1905	1906	1907	1908	1909
Ore, matte and regulus						
Exported to:						
United Kingdom	164	50	206	200	168	258
Germany	102	....	59	188	2	....
Brit. North America	3,486	24,690	36,700	82,016	55,367	50,571
Mexico	15,175	12,948	10,600	16,737	7,060	8,534
Other countries	....	....	54	....	552	520
Total	18,927	37,688	47,619	99,141	63,149	59,880
Ingots and scrap (*b*)						
Exported to:						
United Kingdom	112,224,871	60,945,794	55,097,670	81,409,441	117,810,314	156,511,113
Belgium	9,365,791	4,997,206	6,475,054	3,822,551	5,560,366	6,016,861
France	99,888,455	74,604,455	80,703,723	93,075,145	115,690,381	99,003,962
Germany	103,825,445	104,575,864	96,629,040	107,607,390	137,453,392	138,213,290
Italy	15,297,091	15,800,967	19,777,296	21,192,908	25,512,267	26,386,069
Netherlands	147,678,581	130,675,386	151,650,293	156,652,270	195,562,619	204,378,211
Russia	22,333,578	18,418,982	9,523,992	4,341,386	4,657,077	3,519,216
Other Europe	29,064,494	25,279,162	25,260,807	26,221,024	39,433,674	41,661,979
Brit. North America	3,472,614	3,019,450	4,176,135	3,747,410	3,977,142	6,790,410
Mexico	191,429	290,763	263,319	362,411	35,895	46,287
China	10,403,034	79,940,250	4,932,128	10,003,592	13,735,899	....
Other countries	804,647	16,359,751	262,561	493,873	2,447,101	319,328
Total	554,550,030	534,907,619	454,752,018	508,929,401	661,876,127	682,846,726

(*a*) The exports of ore, matte and regulus are reported as gross weight, the copper contents not being stated
(*b*) Includes bars and plates.

of the last 20 years, or much below the figure upon which conservative engineers and industrialists base their calculations for a long way ahead. The new copper mining enterprises that are brought out with the countenance of competent and conservative engineering advice are seldom based upon a price for copper higher than 13½c. It is well known that the bulk of the North American production of copper yields a profit on the basis of 13c. Otherwise, why should production have increased so hugely in 1909?

The really marvellous thing is that during 1908 and 1909 the price for copper held so steadily at 13c. This resulted primarily from the cheapness of money, which made it easy to finance the accumulation, carried in the hope that absorption would not be long delayed, and, of course, the concentration of the copper selling business in comparatively few strong hands aided in this. Thus the market was kept free from any pressure that might have reduced the price to 10c. or less, as happened in former times, and by naturally restricting the unprofitable output brought production and consumption into equilibrium. So far as productive conditions are concerned there is no reason, so far as we can see, why copper should not be offered at as low a figure as at any time in the past. The exhaustion of some of the rich and cheaply worked mines of former times and the drawbacks of having to work many deposits at increased depth are fully offset by improvements in mining and metallurgy and the discovery of new mines.

Along toward the end of 1909, the widely discussed plan for consolidation of important interests played a prominent part in the copper market. The purpose of this plan was declared to be to improve the price for copper by curtailment of output. Incidentally, it was inferred that its purpose was also to put in a more marketable form various securities that the public would be more interested in buying on a basis of 15c. for copper. This would be, of course, more or less a repetition of the organization of Amalgamated in 1899. Probably the new consolidation would not include any larger proportion of the output than Amalgamated did at that time. The umbrella became too heavy for Amalgamated to hold, and without doubt the situation would become unmanageable to the new combination when such prospective producers as Miami, Ray Consolidated and others will enter the market a few years hence: However, this would be for the public to find out. The Standard Oil decision gave the scheme a rude check. Also the difficulty of reconciling many discordant interests were very great. Consequently, it was decided to effect consolidation in groups, and afterward undertake to bring the groups together. It is now clear, however, that the psychologic time for bringing out the consolidation was missed, and that it was practically defeated by the weight of criticism. The public is now better informed as to the principles of mining valuation than it used to be, and it is less easy to lead investors into gambles in excessively inflated securities.

IMPORTS OF COPPER INTO THE UNITED STATES. (*a*)
(In pounds.)

Country.	1904	1905	1906	1907	1908	1909
Ore and matte						
Imported from:						
Brit. North America..........	15,046,131	15,403,429	10,329,955	12,803,069	11,187,297	9,689,829
Mexico	20,803,961	28,890,239	31,690,058	32,467,418	15,903,692	23,914,040
South America..............	91,509	1,503,427	4,140,589	8,790,621	13,025,614	20,987,197
Other countries..............	3,006,121	4,308,205	2,874,289	5,657,679	16,365,340	26,496,327
Total.....................	38,947,722	50,105,300	49,034,891	59,718,787	56,481,943	81,087,393
Pigs and scrap (*b*)						
Imported from:						
United Kingdom............	19,172,854	26,284,302	22,549,321	25,706,852	5,434,435	26,527,574
France.....................	22,075	1,549,138	3,202,168	606,662	168,506	490,191
Germany....................	875,329	2,945,441	5,303,712	6,814,338	1,451,370	1,045,647
Other Europe...............	16,943	1,955,358	5,649,689	5,616,261	13,359,117	27,379,175
Brit. North America..........	17,690,656	23,636,843	30,398,369	30,902,596	30,895,737	29,196,351
Mexico......................	97,965,593	102,646,343	85,595,359	76,741,532	43,742,993	76,119,724
Cuba........................	368,634	433,440	513,240	767,184	349,560	104,182
West Indies (*c*).............	373,743	278,502	399,569	401,585	184,490	223,408
Japan	80	....	6,752,486	9,809,569	8,329,896	23,830,140
Other countries..............	5,858,535	890,018	16,194,477	35,534,688	58,308,040	55,797,329
Total.....................	142,344,433	160,619,385	176,558,390	192,901,267	162,224,144	240,713,721

(*a*) The imports reported are the copper contents of ore matte and regulus. (*b*) Includes also bars, ingots and plates. (*c*) Includes Bermuda.

We do not seem to be threatened by any dearth of copper. The determination that the low-grade porphyry deposits of Utah and Nevada can be exploited profitably marked the beginning of a new era in copper production and mines of this class are now being rapidly developed in Arizona and New Mexico. It is unbelievable that such deposits are confined to the United States. On the contrary, it is highly probable that similar deposits will be discovered and exploited in Mexico, Chile and other foreign countries, perhaps even in Europe. Indeed, we know of such prospecting, promising well, that has already been inaugurated. It is possible that in admiring the pre-eminence that North America has held in copper producion we have underestimated the possibilities of the rest of the world. Among the new copper districts clearly in view, it is expected that Copper River will produce in 1911 when the railway will be completed. Not much is known respecting the resources of this district, except the Bonanza mine, but the occurrence of copper is widespread, the surface ores are rich and smelting facilities already exist at Tacoma. Katanga is also expected to begin production in 1911. and a great deal of copper is known to exist there, but it will probably be several years before this output attains importance. Both Copper River and Katanga are being developed under adverse natural conditions and their copper will not be produced at anywhere near so low a cost as has been advertised.

The world's production and consumption of copper during the last 11 years as reported by the Metallgesellschaft, Frankfurt am Main, are given in the accompanying table. The figures as to production are somewhat different from our own, but we use them as given in order to match the statistics for consumption as reported. These statistics show an arithmetical average of 15.247c. per lb., and a weighted average of 15.22c. In other words, the world has been willing to pay about 15¼c. for 6,899,600 metric tons of copper used during the last 11 years. The average is, of course, inflated by the extraordinarily high prices that were realized in 1907-08, and we should, therefore, hesitate to say that because the world has bought its requirements for copper during the last 11 years at about 15¼c., the chances are that it will do approximately the same during the 10 years next coming. However, it would seem to us that, taking this long view, an average of 13½ to 14c. might conservatively be expected. Over such a long period the criterion is not the cost of production, but rather what the world will be willing to pay.

WORLD'S PRODUCTION AND CONSUMPTION OF COPPER.
(In tons of 2204.6 lb.)

Year.	Production.	Consumption.	Price. (a)	Year.	Production.	Consumption.	Price. (a)
1899	478,200	467,700	16.67c.	1905	693,900	727,400	15.59c.
1900	499,200	512,700	16.19c.	1906	712,900	727,600	19.28c.
1901	534,800	494,200	16.11c.	1907	703,000	657,300	20.00c.
1902	553,300	582,500	11.63c.	1908	744,600	698,300	13.21c.
1903	591,300	586,700	13.24c.	1909	844,100	782,800	12.98c.
1904	647,900	662,400	12.82c.				
				Totals	7,003,200	6,899,600	15.22c.

(a) Quotational averages, cents per pound at New York.

While history, especially that of the last 10 years, has shown a rather steady forging ahead in production, consumption has experienced a succession of bounds and rebounds, which unbalancing of conditions is, of course, precisely what has been responsible for the great fluctuations in price.

The erratic development of consumption is easily explained by a little reflection, Many years ago there was a very large requirement of copper for sheathing ships. As wooden ships went out of use, a large consumption of copper was cut out, but in the '80s this was much more than made good by the electrical development of the world—first with telephone and lighting plants, next with power plants, then with trolley lines, and finally with long-distance transmission of power. Now this development cannot be expected to go on in geometrical ratio. The most fruitful fields for telephone, lighting, power and trolley plants have already been exploited, and the cream has been skimmed from hydroelectric development. Undoubtedly there will be a new wave of important electrical development—perhaps, indeed very likely, the electrification of the steam railways—but this is not yet fully in sight. We may have to wait several years for such a leap in consumption as we had from 1903 to 1905, and even in the event of such a leap it may not be until a year later that the effect upon price will be fully evident. The overproduction in 1901 caused a fall in price which ranged at a low level until 1905, although consumption increased handsomely and was not greatly out of balance with current production. It was not until 1905 that consumption began sharply to outstrip production and by absorbing accumulations resulted in an extraordinary rise of price.

CONSUMPTION OF COPPER IN THE UNITED STATES. (*a*)

Year.	Production.	Stock Jan. 1.	Imports.	Supply.	Exports.	Stock Dec. 31.	Consumption
1901	597,443,212	93,050,230	176,472,369	866,965,811	227,194,184	197,857,698	440,913,929
1902	636,796,381	209,587,698	161,551,040	1,007,935,119	376,298,726	162,935,439	468,700,954
1903	708,375,228	162,935,439	167,161,720	1,038,472,387	312,822,627	230,111,792	495,537,968
1904	817,715,005	230,111,792	182,292,205	1,230,119,002	555,638,552	208,376,672	466,103,778
1905	875,241,741	208,376,672	210,724,685	1,294,343,098	548,772,403	132,587,496	612,983,199
1906	917,620,000	132,587,496	225,593,281	1,275,800,777	467,839,041	139,385,400	668,576,336
1907	1,152,747,890	9,000,000	5,000,000	1,166,747,890	508,929,401	120,000,000	537,818,489
1908	1,152,895,019	120,000,000	....	1,272,895,019	661,876,127	122,357,266	488,661,623
1909	1,405,403,056	122,357,266	....	1,527,760,322	680,942,620	141,766,111	705,051,591

(*a*) The statistics in the above table up to 1906 inclusive are computed in the old way, namely, on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in *Eng. and Min. Journ.*, July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those for 1906.

ELECTROLYTIC COPPER REFINERIES OF THE UNITED STATES.

(Approximate annual capacity at end of each year.)

Works.	Location.	1906 Capacity, Pounds.	1907 Capacity, Pounds.	1908 Capacity, Pounds.	1909 Capacity, Pounds.
Nichols Copper Company	Laurel Hill, N. Y.	288,000,000	300,000,000	300,000,000	330,000,000
Raritan Works	Perth Amboy, N. J.	288,000,000	300,000,000	300,000,000	320 000 000
American Smg. and Ref. Company	Perth Amboy, N. J.	132,000,000	132,000,000	144,000,000	144,000,000
U. S. Metals Refining Company	Chrome, N. J	144,000,000	144,000,000	144,000,000	144,000,000
Baltimore Cop. Roll. and Mfg. Co.	Baltimore, Md	130,000,000	130,000,000	130,000,000	200,000,000
Balbach Smelting and Refining Co.	Newark, N. J	48,000,000	48,000,000	48,000,000	48,000,000
Boston and Montana Copper Co.	Great Falls, Mont.	48,000,000	48,000,000	48,000,000	48,000,000
Tacoma Smelting Co	Tacoma, Wash	28,000,000	28,000,000	28,000,000	28,000,000
Mountain Copper Co	Oakland, Cal	3,000,000	3,000,000	3,000,000	3,000,000
Chicago Copper Refining Co	Blue Island, Ill	2,000,000	2,000,000	2,000,000	2,000,000
Calumet & Hecla Mining Co. (*a*)	Buffalo, N. Y	25,000,000	25,000,000	25,000,000	25,000,000
North American Lead Co	Fredericktown, Mo	....	2,000,000	2,000,000	2,000,000
Totals	....	1,136,000,000	1,162,000,000	1,174,000,000	1,294,000,000

(*a*) Refines Lake copper.

THE WORLD'S COPPER PRODUCTION.
(In metric tons.)

Country.	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
Africa (a) Cape Co.	4,491	4,064	2,794	4,704	5,563	5,105	4,003	4,298	4,550	4,720
Africa (a) Namaqua	2,337	2,439	1,727	610	2,337	2,337	2,642	2,540	2,440	2,337
Africa (a) Other	....	....	....	....	....	....	....	....	....	8,128
Argentina (a)	76	793	244	137	157	157	107	224	226	610
Australasia (a)	23,368	31,371	29,098	29,464	34,706	34,483	36,830	41,910	40,123	34,952
Austria-Hungary (a)	1,377	1,356	1,626	1,407	1,473	1,346	1,458	1,062	3,877	6,218
Bolivia (a)	2,134	2,032	2,032	2,032	2,032	2,032	2,540	21,035	2,540	2,032
Canada (b)	8,595	18,580	17,765	19,637	19,490	21,595	19,110	2,540	24,376	21,626
Chile (f)	25,715	30,155	27,066	29,923	31,025	29,126	25,829	28,863	42,097	42,726
Cuba (d)	....	....	....	....	....	....	1,384	1,388	2,966	3,006
Germany—total (a)	20,635	22,069	21,951	32,214	30,262	22,492	20,665	20,818	20,523	32,815
(Mansfeld) (a)	(18,684)	(19,082)	(19,050)	(19,810)	(19,578)	(19,878)	(18,085)	(17,343)	(18,000)	(19,015)
Italy (a)	2,797	3,048	3,424	3,150	3,388	2,997	2,911	3,353	3,022	2,769
Japan (f)	24,317	27,392	29,034	31,861	33,187	35,944	36,963	40,183	41,399	42,987
Mexico—total (b)	22,473	33,943	36,357	46,040	51,759	65,449	61,615	57,491	38,190	57,230
(Boleo) (a)	(11,297)	(10,956)	(10,958)	(10,480)	(11,120)	(10,341)	(11,002)	(11,506)	(12,600)	(12,426)
Newfoundland (a)	2,929	2,800	2,906	2,753	2,235	2,316	2,332	1,758	1,453	1,402
Norway (a)	3,998	3,429	4,638	6,010	5,502	6,406	6,218	7,122	9,337	9,226
Peru (e)	8,353	9,673	7,701	9,497	9,504	12,213	13,474	20,681	15,240	16,257
Russia (c)	8,258	8,467	8,817	9,232	9,835	9,515	9,296	15,930	17,718	18,035
Spain-Portugal (a)	53,718	54,482	50,587	50,536	47,788	45,527	50,109	50,470	53,425	53,023
Rio Tinto (a)	36,304	35,916	35,032	36,382	34,016	32,795	34,642	32,833	35,517	35,938
Tharsis (a)	8,092	7,546	6,817	6,421	5,710	4,415	4,816	4,206	4,500	4,425
Mason & Barry (a)	3,515	3,789	3,383	2,469	2,997	2,764	2,504	2,662	2,804	2,403
Sevilla (a)	1,483	1,313	1,570	1,123	1,351	1,300	2,073	2,337	2,196	1,849
Sweden (c)	136	137	178	776	533	1,385	1,209	1,577	2,808	2,032
Turkey (a)	2,341	1,665	1,118	1,422	965	711	432	1,270	1,068	813
United Kingdom (g)	777	541	490	545	501	727	762	677	588	....
United States (d)	272,610	271,072	293,053	312,631	400,998	397,069	416,343	398,930	430,099	501,372
Total	491,435	529,508	542,606	630,590	693,240	698,931	715,510	724,120	758,065	854,316

(a) As reported by Henry R. Merton & Co., Ltd., of London. (b) As reported by Henry R. Merton & Co., previous to 1905, subsequently as reported by the *Eng. and Min. Journ.* (c) As officially reported except for 1909, for which year the figure of Henry R. Merton & Co. is used. (d) As reported by the *Eng. and Min. Journ.* (e) As reported by Henry R. Merton & Co. for 1900–1902, as officially reported 1903–1907, as per Henry R. Merton & Co. for 1908 and 1909. (f) As officially reported. (g) As officially reported, 1900–1905; subsequently as per Henry R. Merton & Co.

WORLD'S PRODUCTION OF COPPER. (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1880	156,500	172,547	1890	274,065	302,166	1900	491,435	541,561
1881	166,065	183,093	1891	280,138	308,862	1901	529,508	583,517
1882	184,620	203,550	1892	309,113	340,808	1902	542,606	597,951
1883	202,697	223,481	1893	310,704	342,562	1903	630,590	694,910
1884	223,884	246,840	1894	330,075	363,920	1904	693,240	764,758
1885	229,315	252,828	1895	339,994	374,856	1905	698,931	770,221
1886	220,669	243,295	1896	384,493	423,917	1906	715,510	788,492
1887	226,492	249,716	1897	412,818	455,147	1907	724,120	798,205
1888	262,285	281,179	1898	441,282	486,529	1908	758,065	835,623
1889	265,516	292,741	1899	476,194	525,021	1909	854,316	941,721

(a) The statistics for 1880–91 are as reported by Henry R. Merton & Co.; 1892–1909 as per *The Mineral Industry.*

The Price for Copper in 1909.—The majority of the copper producing companies having submitted their official reports for 1909, the *Eng. and Min. Journ.* made its usual analysis of the price that they received for their product, in comparison with its own quotational averages. Thirteen Michigan companies reported as shown in the accompanying table. The list includes all of the important companies with the exception of Calumet & Hecla. Their sales aggregated about 136,000,000 lb., which is considerably upward of 50 per cent. of the total Lake Superior production in 1909. The average price received from these sales of copper was 13.221c. per ℔., against the quotational average of 13.335c. per ℔. As usual, the Quincy company leads the list, its average having been 13.48c. This figure, however, includes its proceeds from silver, and if the latter were segregated, the average for copper would probably be in the neighborhood of 13.40c. per ℔. The lowest figures are reported by the companies producing the arsenical grade of copper, their figure in each case being 13c. The arsenical copper is sometimes sold on equal terms with prime Lake copper, but sometimes it is marketed at a discount, which apparently was the case in 1909. Excluding this copper, amounting to 46,187,221 ℔., the sale of 89,818,552 ℔. realized an average of 13.338c. per ℔., against the quotational average of 13.335c.

LAKE COPPER SALES IN 1909.

Company.	Pounds.	Amount	Average.	Company.	Pounds.	Amount.	Average.
Ahmeek	8,900,523	$1,190,000	13.37	Michigan	1,979,305	260,551	13.16
Allouez	3,164,608	419,628	13.26	Mohawk	11,248,474	1,484,292	13.20
Baltic	17,817,836	2,315,035	13.00	Osceola	24,659,729	3,279,743	13.30
Centennial	2,583,793	343,050	13.277	Quincy	22,511,984	3,034,810	13.48
Champion	18,005,071	2,339,362	13.00	Tamarack	13,118,785	1,747,422	13.32
Franklin	1,651,351	221,085	13.39	Trimountain	5,282,404	686,332	13.00
Isle Royale	5,081,910	660,440	13.00	Totals	136,005,773	$17,981,750	13.221

Comparison between the price actually realized and the quotational averages for the last five years is made in another table. The actual averages in each year are somewhat low, owing to the inclusion of the arsenical copper, the difference on its account being variable, as explained above.

AVERAGE PRICE REALIZED FOR LAKE COPPER. (*a*)

Year.	Number of Companies.	Pounds Reported.	Total Proceeds.	Price per Pound.	Quotational Average.
1905	9	82,372,955	$12,848,152	15.597c.	15.699c.
1906	13	113,411,645	21,714,068	19.146c.	19.616c.
1907	10	66,316,025	11,965,537	18.043c.	20.661c.
1908	15	125,949,248	16,907,498	13.348c.	13.424c.
1909	13	136,005,773	17,981,750	13.221c.	13.335c.

(*a*) The statistics in the above table are compiled from the official reports of Michigan copper mining companies, except the column called "quotational average" which gives the figure reported by the *Eng. and Min. Journ.* This figure is the arithmetical mean of its monthly averages, which in turn are the arithmetical mean of the daily quotations. In general, the weighted average computed from the sales actually made by these companies agrees closely with the quotational average, but for 1906 and 1907 it was materially lower, owing to the highly erratic and exceptional character of the business in those years, particularly 1907, when for a long period quotations were made on comparatively small sales, while many of the producers were accumulating unsold stocks of metals, which were finally disposed of at relatively low prices. This was the year when the price of copper fell from upward of 25c. to less than 12c. per pound.

In another table is summarized the reports of seven producers of electrolytic copper, whose sales aggregated about 216,000,000 lb., at an average of 13.008c. per lb. The quotational average for electrolytic copper in 1909 was 12.982c. per lb.

ELECTROLYTIC COPPER SALES IN 1909.

Company.	Pounds.	Amount.	Average.	Company.	Pounds.	Amount.	Average.
Balaklala	7,944,294	$1,028,664	12.949	Superior & Pittsburg	24,325,667	3,173,770	13.047
Calumet & Arizona	27,630,050	3,604,893	13.047	United States	36,672,606	4,769,639	13.006
North Butte	33,102,153	4,340,685	13.113	Utah	51,749,233	6,683,413	12.915
Old Dominion	34,519,301	4,490,961	13.010	Totals	215,943,304	$28,092,025	13.008

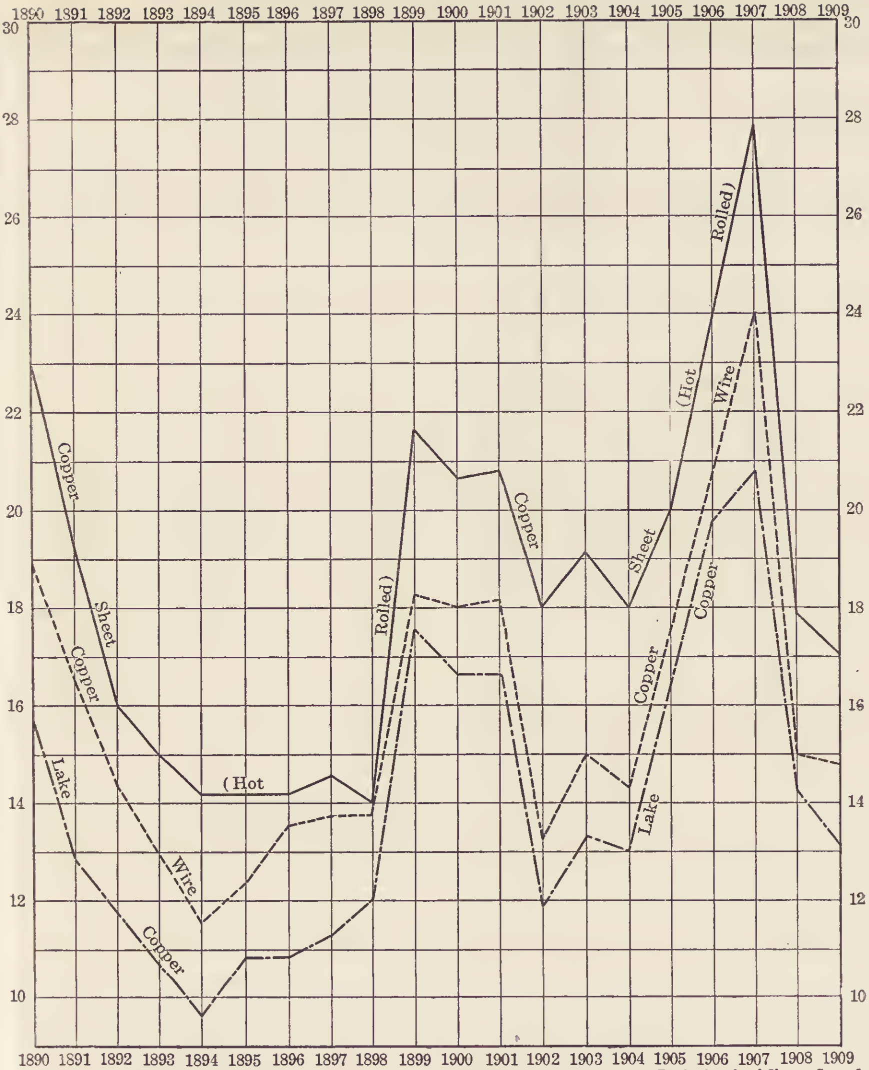
For the first six months of 1909 we have available the statistics of the constituent companies of the Amalgamated Copper Company, through its reports to the New York Stock Exchange under date of Feb. 14, 1910. This report shows sales of 93,415,241 lb. of copper during that semester, at an average of 12.918c. The quotational average for the same period was 12.983c.

SALES IN FIRST HALF OF 1909.

Company.	Pounds.	Amount.	Average.
Boston & Montana	42,654,381	$5,498,097	12.89
Butte & Boston	8,609,195	1,114,780	12.95
Parrot	2,968,356	383,344	12.91
Trenton	3,267,973	423,010	12.94
Washoe	35,915,336	4,647,665	12.94
Totals	93,415,241	$12,066,896	12.92

The average reported by the producers of electrolytic copper in 1909 ranged from 13.11c., reported by North Butte, down to 12.92c., reported by Utah. It is unwise, however, to attempt to draw too fine comparisons among the reports of these companies, inasmuch as they are not specific as to precisely what is represented. In some cases, at least, they include the cost of time and delivery, and consequently, are in excess of the net price actually received, basis New York. These conditions do not enter into the reports of the Michigan companies to the same extent.

The accompanying diagram is interesting because of its graphic presentation of the relative price of bar copper and the chief primary manufacturers, meaning sheet and wire. In an editorial in the *Eng. and Min. Journ.* of Feb. 26, 1910, were discussed the conditions under which the price for these manufactures is established.



GRAPHIC COMPARISON OF THE PRICE OF COPPER AND ITS CHIEF MANUFACTURES

The lines in the diagram are plotted from the annual averages, the figures for Lake copper being as reported by the *Eng. and Min. Journ.*, while the figures for sheet and wire are as reported by the Department of Commerce and Labor up to 1908; for 1908 and 1909 as reported by the *Eng. and Min. Journal.*

It would be preferable to make comparison with the price for electrolytic copper, but unfortunately data for that class of metal do not go further back than 1899, and consequently we have taken the figures for

Lake copper in order to possess uniformity in the diagram, covering the period of 20 years. However, the line for electrolytic copper since 1898 would be substantially parallel to the line for Lake copper.

Review of Copper Mining by States.

Alaska.—Production in 1909 was about the same as in 1908. The entire product of this Territory was finally smelted at Tacoma, a portion being first treated at the Tyee works in British Columbia, and thence shipped to Tacoma as matte. Progress was made in the construction of the railway to the Copper River district, and it is expected that the mines will be reached by the end of 1910, but they will hardly begin to produce before 1911. In the meanwhile active development work is being prosecuted at the most important mine.

Arizona.—The production in 1909 was about the same as in 1908. There were no new producers of blister copper, but two companies were planning to install converters. Preparations were made also to resume smelting at the Humboldt plant. The Miami and Ray Consolidated companies were engaged in the construction of large concentrating mills, which probably will be completed about the end of 1910, or early in 1911. Ray Consolidated is also considering the erection of a smelting works.

The copper-sales department of Phelps, Dodge & Co., marketed, in 1909, 185,033,415 lb. of copper. Dividends amounting to $5,396,652 were paid, and the company carried forward a surplus of $446,559 at the close of the year. During the year the Burro Mountain copper mines, in New Mexico, were acquired and partially paid for. It is intended to hold this property as a reserve; about 2,000,000 tons of ore have already been exposed in it.

COPPER QUEEN MINES PRODUCTION, 1909.

	Tons.	Copper. lb.	Silver. Oz.	Gold, Oz.
Mined and shipped to reduction works....	566,518	83,010,976	585,075	8,239
Mined and shipped to other points........	28,833	1,249,807	7,777	405
Precipitates made and shipped to Douglas.	272	169,008	76	....
Total............	595,623	84,429,791	592,928	8,644

The production of the Copper Queen mines is given in an accompanying table. The following development was done: Shafts, 308 ft.; drifts, 45,363; raises and winzes, 14,649 ft. New ore-bearing territories were discovered and partially developed at several points, notably in the Uncle Sam country, on the lime contact with the western boundaries of the Sacramento hill porphyries and in the lower levels of the Lowell mine. Mining is carried on by the square-set system. Superintendent Gerald Sherman says: "As we extract most of our ore from irregular masses embedded in great bodies of soft, decomposed material which is in constant motion, we cannot block out ore for purposes of measurement. But I can state that there is as much ore in sight today as at any period during the past 10 years while I have been manager of the property."

PRODUCTION OF COPPER QUEEN SMELTERY.

	Tons Treated.	Copper, lb.	Silver, Oz.	Gold, Oz.
Copper Queen ores and precipitates........	544,963	75,466,772	534,151	8,938
Copper Queen slags and cleanings (Bisbee)...............	7,669	402,633	87	....
Moctezuma ores and concentrates........	112,563	24,814,747	421,648	1,054
Custom ores..........	70,295	7,858,812	1,623,925	22,160
Total Production.	735,490	108,542,964	2,579,811	32,152

At the Copper Queen smeltery there were in operation an average of 7.5 blast furnaces and 5.8 converter stands, the plant consisting of 10 blast furnaces and eight stands of converters.

COPPER QUEEN STATISTICS

Year.	Production, Pounds.	Net Earnings.	Dividends.
1903..................	37,257,470	$2,201,640.40	$ 800,000
1904..................	50,151,552	2,960,659.70	800,000
1905..................	64,625,955	5,609,486.30	2,300,000
1906..................	79,219,655	7,625,854.76	6,500,000
1907..................	63,341,055	4,471,137.08	3,800,000
1908..................	76,125,162	....	3,000,000
1909..................	84,429,791	5,271,278.20	4,025,000

The difference between earnings and dividends is represented by expenditure on increased plant facilities, and undistributed. Since 1887 the company has paid a total of $34,085,000 in dividends.

The Detroit Copper Mining Company in 1909 mined 449,977 tons of concentrating ores, 8898 tons of smelting ore, and 10,007 tons of silicious ores for converter linings. The concentrating department reports that 451,642 tons of Detroit ore assaying 3.106 per cent. copper, were concentrated, producing concentrates assaying 15.85 per cent. copper, and making an extraction of 78 per cent. The tailings assayed 0.8 per cent. copper; concentration ratio was 6.57 : 1; 332 gal. water were used per ton of ore milled; and 1293 tons were milled for each 24 hours' actual running time. The smelting and converting department reports a saving of 94.5 per cent.

ORES SMELTED, 1909, DETROIT MINING COMPANY.

	Tons Ore Treated.	Bullion Produced, lb.	Assay of Original Ore. Per Cent. Copper.	Yield in Bullion per Ton Ore. Per Cent. Copper.
Concentrating ore........	449,357	20,430,650	3.106	2.273
Smelting ore............	8,753	2,547,000	15.39	14.55
Silicious ore to converters.	7,650	770,560	5.316	5.03
Total Detroit ore treated at Morenci works......	465,760	23,748,210	3.373	2.55
Silicious ore shipped to Douglas..............	2,340	243,385	5.77	5.2
Total Detroit ores treated at Morenci and Douglas	468,100	23,991,595	3.385	2.562
Purchased ores treated at at Morenci............	4,150	599,426	8.191	7.22
Total ores...........	472,250	24,591,021	3.427	2.605

DETROIT COPPER MINING COMPANY.

Year.	Production. lb.	Net Earnings.	Dividends.(a)
1903..................	16,869,300	$ 543,456.00	....
1904..................	16,424,394	603,340.00	....
1905..................	14,632,117	532,684.28	....
1906..................	20,347,497	973,456.42	....
1907..................	17,974,581	814,874.11	$80,000
1908..................	24,223,172	1,072,016.00	480,000
1909..................	24,591,021	1,153,269.66	760,000

(a) The company had paid a total of $5,717,590 in dividends up to the end of 1909.

The Calumet & Arizona Mining Company in 1909 produced 13,815 tons of refined copper from 327,807 tons of ore, or 83.93 lb. copper per ton of ore. The value of the gold and silver recovered was $211,760. Average number of men employed, 1274; 805 at the mine and 469 at the smeltery. During the year four dividends, amounting to $800,000 were paid. Operating expenses were $2,313,509; construction account, $161,-588; salaries and general office expenses, $30,853; freight, refining and marketing, $333,315. At the mines at Bisbee, Ariz., development work was carried on at the Oliver, Irish Mag and Powell shafts, making a total of 27,562 ft. of drifts, winzes and raises. The Oliver shaft is 1375 ft. deep, or 50 ft. below the 1450-ft. level, which is counted from the Irish Mag shaft. The most satisfactory result of development during the year was the cutting of a large sulphide orebody on the 1350-ft. level, which has proved to be of larger dimensions and more uniform than on the upper level. This has proved to be the largest sulphide orebody found in the Calumet & Arizona properties. At the smeltery at Douglas, furnaces Nos. 5 and 6 were rebuilt during the year. The three large furnaces are 25 ft. x 44 in., and have a capacity of 500 tons each per day. The total capacity of the smeltery is 2400 tons per day.

CALUMET & ARIZONA MINING COMPANY.

Year.	Net Earnings.	Copper Produced, lb.	Price Received.	Gold and Silver Value.	Gross Product.	Cost Per lb.
1903	$1,341,474	25,535,857	11.558c.	$144,862	$3,096,807	6.89c.
1904	1,682,518	31,638,660	12.562c.	195,926	4,170,374	7.86c.
1905	2,314,268	31,772,896	14.932c.	178,843	4,923,172	8.21c.
1906	4,827,872	37,470,284	17.96c.	238,464	6,968,127	5.71c.
1907	2,114,047	30,689,448	18.102c.	210,846	5,765,636	11.22c.
1908	857,700	28,048,329	12.948c.	234,358	3,859,854	11.00c.
1909	1,214,495	27,630,050	13,531c.	211,760	3,950,311	10.38c.

The Superior & Pittsburg Copper Company in 1909 mined and smelted 257,042 tons of ore (wet weight), from which 24,623,339 lb. of blister copper were produced, or a yield of 4.754 per cent. The value of the gold and silver recovered during the year was $164,305. An average of 554 men were employed. Operating expenses were $2,113,880 ($8.22 per ton); construction, $13,673; general expenses, $29,888; freight, refining and marketing, $322,243.

STATISTICS OF UNITED VERDE COPPER COMPANY.

	1906	1907	1908	1909
Copper production, lb.	....	33,012,339	36,183,089	36,694,063
Silver production, oz.	....	....	494,574	495,480
Gold production, oz.	....	11,730	20,334	17,022
Cost of mining	....	$1,068,293	$ 796,529	....
Cost of smelting	....	1,281,674	1,215,993	....
Charged to depreciation	....	298,243	320,407	....
Price received for copper, per lb.	20.22c.	18.167c.	13.343c.	....
Price received for silver, per oz.	67.435c.	64.158c.	52.453c.	....
Price received for gold, per oz.	$20.50	$20.50	$20.50	....
Cost of copper, per lb (*a*)	8.69c.	10.54c.	9.046c.	....

(*a*) Value of the precious metals is not credited against cost of producing the copper.

The Arizona Copper Company, in the year ended Sept. 30, 1909, produced 741,068 tons of ore, which yielded 31,573,950 lb. of copper, or 42.49 lb. per ton of ore. In addition to the above ores there were mined and shipped 129,031 tons of limestone flux, making a grand total of ores and fluxes of 870,099 tons, as compared with 856,669 tons for the previous year. The operating cost was £616,541, and general charges £22,042. After paying preferential dividends to the amount of £24,531, and an ordinary dividend of 2s. 6d. per share, and transferring £80,000 to reserve account, a balance of £39,994 was carried forward. The grade of ore treated was slightly lower than during the previous year. Fuel oil was substituted for coal at Clifton and Longfellow, the saving from which is estimated at $25,000 to $30,000 per year.

The Shannon Copper Company in its fiscal year ended Aug. 31, 1909, produced 307,271 tons of ore, of which 186,453 were of smelting grade and 120,808 were concentrating. The production was 17,553,213 lb. of fine copper, 1745 oz. of gold and 87,116 oz. of silver. Operating expenses amounted to $2,007,365; development and exploration, $48,221; freight, refining and Eastern expenses, $272,671.

According to a report by D. C. Jackling, general manager of the Ray Consolidated Copper Company, the site selected for this company's mill is on the north bank of the Gila river, directly opposite the point where the San Pedro joins the Gila, and about a half a mile from the Phœnix & Eastern Railway. A geological study of the Ray mine has been made by Spurr & Cox. They report that the orebodies consist, generally speaking, of secondarily mineralized bodies of altered schist, associated with smaller masses of granite porphyry, more or less altered, and mineralized similarly to the schist. Of the 1000 acres of mining ground owned by the Ray company, about 470 acres show indications of thorough primary mineralization. According to the report of Henry Krumb, engineer for the company, development by churn drilling up to the end of September, 1909, had shown the existence of ore somewhat exceeding 38,000,000 tons, averaging 2.26 per cent. copper; area of ore, 95.9 acres; average thickness 114.7 ft.; average thickness of capping 240.1 ft. The concentrating mill will have an initial daily capacity of 5000 tons. The experimental mill after running for about 10 months, treating 100 to 150 tons per day, is considered to have proved that an extraction of about 70 per cent. of the copper content of the ore can be made, and that the concentrate will assay about 27 per cent. copper.

According to a report by J. Parke Channing in October, 1909, 40 acres of the mineral ground of the Miami Copper Company has been developed by shafts, drifts, cross-cuts and raises, and may be safely expected to produce 14,000,000 tons of ore, after allowing for losses in mining. As nearly as can be determined, the grade of this ore is 2.75 per cent. copper, from which 40 lb. of copper per ton can be extracted. Estimates indicate that this copper can be produced for 9c. per lb., delivered at New York. Of the 668 acres owned by the company, 250 acres are considered to be mineral ground, of which only 40 have been developed. Probably 60 acres contain nothing, leaving 150 acres with good prospects. The mill now under construction is expected to treat 700,000 tons of ore per year. The ore will be concentrated at the ratio of 20:1, the mill being expected to produce about 100 tons of concentrate daily, assaying 40 per cent. copper.

The Gila Copper Company in an official report reviewing its operations up to Dec. 18, 1909, stated that the company owns about 950 acres adjoining the Ray Consolidated. About 275 acres of more or less mineralized schist is classified as 110 acres showing thorough primary mineralization and 165 acres of less mineralized ground. Churn drilling is considered to have proved 12,237,000 tons of ore, averaging 2.05 per cent. copper, which is included in 19.7 acres. Of this ore 10,500,000 tons are in the Sun orebody. The average thickness of the capping is 306 ft., and of the ore 177 feet.

(By James Douglas.)—The most notable feature of Arizona's copper mining during 1909 was in the direction of the development of deposits of low-grade ores in porphyry and schists. The greatest activity has been in the Globe district. The country between Pinal creek, which runs through the town of Globe, and the Pinal mountains, which are 20 miles south of Globe, is more or less impregnated with copper, and it is within that district that the most vigorous operations are now being conducted. Some of the properties which are to be worked by large public corporations have been small producers for a number of years, but nowhere have they been prospected in depth, and it is the deeper ores which under corporate management will unquestionably tell largely upon Arizona's future production.

The most prominent of the new properties is the Miami, which is being opened under the management of J. Parke Channing. The concentrating mill was designed and is being erected under the supervision of H. Kenyon Burch. It should, therefore, be an improvement upon the successful mills which have been built under his direction for the Detroit Copper Mining Company and the Moctezuma Copper Company.

Adjacent to the Miami, the Inspiration and Black Copper are being opened up, and the Live Oak, Black Warrior and Eureka (renamed the Cordova since consolidation with the Globe Consolidated), all promise to become more prolific producers in the future than they have been in the past. The Cactus company is another new company which is appealing to the public for support. Its mines are about four miles west of the Miami. The Gibson Copper Company is still producing, and mines are being opened in the neighborhood of Bloody Tanks, a district historically interesting in that the first furnaces put up by the Old Dominion company in 1881 were erected there to treat the ores of the Chicago & New York.

To the north of Pinal creek, where are the properties of the Old Dominion and United Globe mines, the Arizona Commercial Company has passed from the passive stage of a mere ore producer into the active stage of a smelting enterprise, and is turning out at the start about 25 tons of 50 per cent. matte per day. Other companies working on the northern extension of the more or less developed Globe veins are the Superior & Boston and the Cordova, which has absorbed the Globe Consolidated.

Another district which is appealing to the public for support is what is known as Mineral creek, south of the Pinal mountains. The Ray mine has been more or less actively worked for the last 24 years, and has passed through various reorganizations. The last is the Ray Consolidated. Another company in the same neighborhood is the Ray Central. The Gila Consolidated is a third candidate appealing for public help. All these companies are capitalized at very high figures, and are developing enormous quantities of ore with churn and diamond drills. If their expectations are realized, the quantity of copper they will turn out will certainly supply all the world will require.

The Saddle Mountain mines have been taken over by the Development Company of America, and their product will be smelted at the Sasco smeltery.

The only other new district in the Southwest in which the same quality of ores is being exploited is in the Silver City District of New Mexico. The Chino company, reviving and actively working the old Santa Rita mines, which have for years been abandoned to the tender mercies of tributers. And the Burro Mountain mines are being actively explored. They are situated in New Mexico a short distance east of the Arizona line. The Comanche Mining Company, now consolidated with a neighboring concern as the Savannah Copper Co., has been mining these low-grade ores for several years with indifferent success; but more extensive operations were conducted by the Burro Mountain and Chemung companies on an adjacent group of claims. Although the Burro Mountain Company has treated the ores, necessarily extracted, in a small mill, neither of these companies has reached the point where it can confidently predict the cost of making copper.

On the testimony of churn drills and diamond drills we are measuring ore by the millions and millions of tons, and estimating its value to the tenth of a per cent., and counting the costs and the profits on prophetic anticipations of what mills will do and what prices will be. It is a wild game in which the public is generally the pawn and the players stand small danger of losing. In no case have active operations proceeded far enough to raise the value of these properties out of the speculative into the realized class.

One inducement to capitalists to undertake the exploitation of these deposits has been the success of the Clifton companies in working profitably ores of 3 per cent. and under, though they do not carry precious metals in profitable quantities. In this respect they are at a disadvantage with the porphyry mines of Utah, Nevada and British Columbia. But the present position of the Clifton mines was earned by many years of financial trial and was gradually attained by experience as the grade of the ore dropped from 10 or 15 per cent. to its present level. The new undertakings start with even leaner ores than Clifton, but with the information derived from their neighbors' operations, and with the additional advantage of perfect knowledge of the great advance made within recent years in mining and metallurgy. The reduction in the cost of mining through the introduction of the caving and slicing systems, has, where conditions are favorable, cut in two the expense of underground mining; and the steam shovel, applied to opencast work, has reduced such mining to the level of railroad grading. Mineral, therefore, which could not have been classed as ore 20 years ago is today worked to a profit. And the ore when extracted can be handled with ever decreasing cost, both mechanically through the concentrating mill, and metallurgically through the smelting works. It is therefore presumptuous to pretend to define what is the minimum grade that under certain favorable circumstances can be profitably treated. Nevertheless another factor enters into the question of what is a profitable ore, besides the cost of turning it into metal and marketing it and that is the price that is going to be realized for the metal. If there is any relation between production and consumption in controlling price, unlimited production must mean limited price. When, therefore, these new concerns talk lightly of building mills of 5000 and 6000 tons daily capacity instead of 1000 or 2000, they must have some assurance of a buoyant market, which will put the red metal to new uses.

These courageous projects cannot, however, be expected to increase notably Arizona's production during the coming year. The mills are not yet erected, nor the mines sufficiently opened to furnish with ore the mills of such large contemplated output.

The production of Arizona in 1909 was approximately the same as it was in 1908, say, 291,000,000 lb. As Butte has with but slight interruption been active throughout the year, Montana may be expected to again take the lead by a small excess. The copper statistics of Arizona are liable to be confused if the product of the Copper Queen smelting works at Douglas is credited wholly to the Territory. The copper smelted at the Copper Queen works during 1909 may be roughly distributed as follows: Copper Queen ores, 75,821,566 lb.; Custom (domestic), 7,704,-997 lb.; Moctezuma Copper Company, 23,936,000 lb.

The output of the Copper Queen mines during 1909 was 75,821,566 lb., as compared with 76,125,162 lb. in 1908, and 61,701,862 lb. in 1907. The Calumet & Arizona works at Douglas produced approximately 52,142,-664 lb., of which 27,793,322 lb. are credited to the Calumet & Arizona and 24,349,332 lb. to the Superior & Pittsburgh. Some ore, however, has recently reached these works from the property of the Calumet & Arizona at Courtland. The other producing company of that district, the Great Western, is shipping its ore to El Paso. Shipments from this source have only recently commenced, and have reached about 10,000 tons. The developments at Courtland do not yet warrant the anticipation that this new district will become a prolific producer.

Clifton's output was approximately 74,059,948 lb. as against 74,596,-897 lb. in 1908, and that of the Old Dominion furnaces in Globe was approximately 35,027,576 lb., as against 37,840,587 lb. in 1908. The quantity of custom ore which was shipped to the smeltery at Globe fell off after the absorption of the properties which yielded it by the large corporation recently formed and which is reserving the resources for more economical treatment.

The only other smelting establishment which has been in blast is the Sasco smelter, its furnaces turning out approximately 11,000,000 lb. of copper during 1909. The company states that it proposes to enlarge the plant during the coming year.

It is not contemplated to increase any other of the smelting plants during 1910, but the success attained in Cananea in reverberatory smelting with the use of oil as fuel has suggested very radical alteration in those establishments which have to treat large quantities of concentrates and retreat large quantities of flue dust.

The two neighboring districts in northern Sonora which have been closely allied with Arizona enterprises, Cananea and Nacozari, have been active. At Cananea good management has brought the cost of copper within profitable bounds, and Nacozari has increased its output, and continues to ship its concentrates to the Copper Queen furnaces at Douglas. The Transvaal company has not resumed production.

The Indiana-Sonora property, which used to ship its crude ores to Douglas for reduction, was absorbed by the Greene-Cananea company.

The forecast for 1910 is that all the companies will maintain their present production. Some can easily exceed it, but it would be injudicious in the present state of the market to do so. But there is no reason to suppose that any one will cut down production beyond the present limits. Changes if made in the furnace plants, will be in the direction of improved methods, not of increased capacity.

California.—The increased operations by Mammoth and the steady operations by Balaklala, added largely to the production of California in 1909, and this State is doubtless destined to make further gains in the near future. Mountain made only a small output in 1909, but has ore reserves enabling it to increase largely when it gets ready. The mines and smelting works of Shasta county, Cal., were described with much detail in an article by George A. Packard in *Eng. and Min. Journ.* of Aug. 28, 1909.

Colorado.—The copper production of this State, which continues small, fell off materially in 1909.

(By George E. Collins.)—There are no exclusively copper mines in Colorado. The major part of the output comes from gold-silver ores produced in Gilpin, Clear Creek and Lake counties, and from the San Juan district. In Hinsdale county the Frank Hough, a copper-bearing vein on Engineer mountain, just north of the San Juan line, was the most promising and perhaps the most important producing mine. The San Antonio, in the Red Mountain district, also made notable shipments of high-grade copper ore.

Idaho.—The production of this State in 1909 was smaller than in 1908. The Snow Storm mine, in the Cœur d'Alene, continued to be the chief producer. All of the copper ore of Idaho is shipped to other States for smelting, a little being exported to British Columbia.

(By F. Cushing Moore.)—Outside of the Cœur d'Alene, the only copper producing district of importance in Idaho is the Seven Devils. This district, which has been worked in a desultory way for many years, has lately presented the appearance of healthy development. The Salt Lake Copper Company, controlled by the Lewisohns, has taken options on some of the more important properties.

Michigan.—Production increased considerably over 1908. It could readily have been increased further, but Calumet & Hecla restricted its output of refined metal, adding to its accumulation of "mineral." There were several new producers, but none of particular importance except Superior, although some others, especially Lake, promise to figure prominently in the near future. An important event of 1909 was the passing of the Bigelow properties to the control of the Calumet & Hecla, thus terminating the litigation between these interests. The discovery of what is believed to be the extension of the Baltic lode on lands north of Portage Lake may prove of benefit to the district, and the continuation of the Lake lode may mean the opening of mines in Ontonagon county, which heretofore have been disappointing.

COPPER PRODUCTION IN MICHIGAN.
(Pounds of fine copper.)

Mines.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Adventure..	....	606,211	2,182,608	1,380,480	1,606,208	1,552,628	1,244,872	90,870	*Nil.*
Ahmeek....	....	....	....	350,000	1,552,957	3,077,507	5,527,672	6,280,241	9,198,110
Allouez.....	....	....	....	....	1,167,957	3,486,900	2,934,116	3,047,051	4,031,532
Atlantic....	4,666,889	4,949,368	5,505,598	5,321,859	4,049,731	1,439,082	*Nil.*	*Nil.*	43,483
Baltic......	2,641,432	6,284,819	10,580,997	12,177,729	14,384,684	14,397,557	16,704,868	17,724,854	17,817,836
Cal. & Hecla	82,519,676	81,248,739	76,490,869	80,341,019	83,812,370	94,529,821	88,055,723	81,660,723	74,593,553
Centennial..	806,400	....	....	641,294	1,446,584	2,253,015	2,373,572	2,196,377	2,853,793
Champion ..	....	4,165,784	10,564,147	12,212,954	15,707,427	16,954,986	16,489,436	17,786,763	18,005,071
Franklin ...	3,757,419	5,259,140	5,309,030	4,771,050	4,206,085	4,571,570	4,401,248	3,703,421	1,615,556
Isle Royale .	2,171,955	3,569,748	3,134,601	2,442,905	2,973,761	2,937,098	2,667,608	3,011,664	5,719,015
Mass	837,277	2,345,805	2,576,447	2,182,931	2,007,950	2,106,739	2,078,677	1,766,930	1,723,436
Michigan...	....	166,898	275,708	2,746,127	2,891,796	2,875,341	2,665,404	3,000,206	1,979,305
Mohawk ...	160,897	226,824	6,284,327	8,149,515	9,387,614	9,352,252	10,107,266	10,295,881	11,248,474
Osceola.....	13,723,571	13,416,398	16,059,636	20,472,439	18,938,965	18,588,451	14,134,753	21,250,794	25,296,657
Phoenix....	93,643	....	202,823	1,162,201	273,219	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Quincy	20,540,740	18,988,491	18,498,288	18,343,160	18,827,557	16,194,940	19,796,058	20,600,361	22,511,984
Tamarack ..	18,000,852	15,961,528	15,286,093	14,961,885	15,824,008	9,832,644	11,078,604	12,806,127	13,533,207
Trimountain	....	5,730,807	9,237,051	10,211,230	10,476,462	9,507,933	8,190,711	6,034,908	5,282,404
Winona	....	101,188	1,036,944	646,025	*Nil.*	278,182	1,285,863	*Nil.*	*Nil.*
Wolverine..	4,946,126	6,473,181	8,999,318	9,764,455	9,464,418	9,548,123	9,273,351	9,555,233	9,971,482
Victoria....	....	....	....	....	....	....	1,207,237	1,290,040	1,062,218
Others......	640,591	700,067	75,000	50,000	....	....	100,000	....	1,030,882
Totals....	155,507,465	170,194,996	192,299,485	208,392,485	218,999,753	224,071,103	220,317,041	222,267,444	227,247,998

STATISTICS OF MICHIGAN COMPANIES IN 1909.

Name.	Tons Milled.	Production. of Copper in lb.	lb. of Refined Copper per Ton Milled.	Cost of Mining and Milling per Ton.	Total Cost per lb. of Refined Copper.
Ahmeek..............................	406,045	9,198,110	22.7	$1.72	15.48c.
Allouez..............................	253,049	4,031,532	15.93	1.54	13.39c.
Baltic..............................	814,260	17,817,836	21.88	1.554	7.98c.
Centennial..............................	196,525	2,583,793	13.15	1.818	15.61c.
Champion..............................	753,908	18,005,071	23.88	1.804	8.45c.
Franklin..............................	170,546	1,615,556	9.47	1.941	13.35c.
Isle Royale..............................	401,280	5,719,015	14.3	1.87	16.64c.
Mass..............................	139,404	1,723,436	12.36	(?)	(?)
Michigan..............................	148,172	1,979,305	13.36	(?)	(?)
Mohawk..............................	819,019	11,248,474	13.73	1.40	11.207c.
Osceola..............................	1,494,845	25,296,657	16.9	1.36	9.47c.
Quincy..............................	....	22,511,984	....	....	9.98c.
Tamarack..............................	689,099	13,533,207	19.6	2.44	14.30c.
Trimountain..............................	323,408	5,282,404	16.33	2.09	13.89c.
Victoria..............................	118,605	1,062,218	8.96(?)	1.22(?)	17.09c.(?)

Montana.—In this State there was a large increase in copper production in 1909 and it regained its former place as the premier among the States of the Union. The Washoe and Great Falls works were run at practically full capacity throughout the year, except in December, when the switchmen's strike interfered. The other smelting works in operation were the Colusa-Parrot and the Pittsmont.

The Amalgamated Copper Mining Company and its constituents, which now control the major part of the Butte district have made reports for 1909. The companies owned solely or in part by the Amalgamated Copper Company produced in 1909, from their own and custom

DIVIDENDS PAID BY MICHIGAN MINES.

Mine.	1907.	1908.	1909.	Mine.	1907.	1908.	1909.
Calumet & Hecla	$6,500,000	$1,950,000	$2,700,000	Quincy	$1,485,000	$504,554	$440,000
Copper Range Con	2,000,000	1,205,495	1,536,740	Tamarack	420,000	....	....
Mohawk	900,000	250,000	300,000	Wolverine	1,050,000	600,000	300,000
Osceola	1,249,950	192,300	769,200	Totals	$13,604,950	$4,702,349	$5,045,940

Year.	Dividends.	Year.	Dividends.	Year.	Dividends.	Year.	Dividends.	Year.	Dividends.
1850	$84,000	1870	$700,000	1890	$3,415,000	1902	$3,440,000	1906	$13,231,000
1855	168,000	1875	1,920,000	1895	3,280,000	1903	4,980,000	1907	13,604,950
1860	120,000	1880	3,080,000	1900	9,811,200	1904	5,432,300	1908	4,702,349
1865	510,000	1885	1,970,000	1901	7,496,900	1905	9,224,600	1909	5,045,940

ores, about 292,000,000 lb. of refined copper, of which the Amalgamated received the benefit from about 251,000,000 lb. The production of the several companies is given in the accompanying table.

PRODUCTION OF AMALGAMATED IN 1909.

Company.	lb. Copper.	Oz. Silver.	Oz. Gold.	Company.	lb. Copper.	Oz. Silver.	Oz. Gold.
Anaconda	75,860,194	2,363,184	7,466	Butte & Boston	20,955,910	1,158,672	7,376
Washoe and custom ores	80,559,625	3,500,878	31,161	Trenton	7,168,318	623,728	577
Parrot	5,407,255	308,757	723	Boston & Montana	101,951,350	1,882,046	11.769
				Totals	291,902,352	9,837,268	59,074

According to the Anaconda report, 1,327,291 tons of ore were produced at a mining expense of $5,511,820. Transportation to reduction works, cost, $160,932; reduction expenses, including depreciation, $2,819,021; transportation, refining and selling, $1,163,306; administration, $60,326. The reduction works treated 3,517,386 tons of ore, of which 1,282,681 dry tons were from the company's mines, 139 tons of precipitates, and 15,062 tons of slimes from the old works.

Nevada.—As the Steptoe Valley works approached completion, their production swelled, and the result was a huge increase for the State. At the rate of the last quarter, Nevada Consolidated would produce 70,000,000 lb. in 1910. Steptoe Valley now has four reverberatory furnaces, and the fifth was completed early in 1910. During the fiscal year ended

Sept. 30, 1909, Nevada Consolidated produced 34,527,823 ℔. of copper. The capital stock of the company was increased from 11,600,000 shares to 2,000,000 in order to absorb the Cumberland-Ely, the shares of the latter being exchanged for Nevada Consolidated in the ratio of $3\frac{1}{2}:1$.

ANACONDA STATISTICS.

	1909.	1908.	1907.	1906.
Copper, ℔.	75,860,194	64,869,170	63,055,661	94,963,835
Silver, oz.	2,363,184	2,071,246	2,001,350	2,979,908
Gold, oz.	7,466	8,395	8,290	15,885
Min. exp. dev. dep.	$2,720,908	$4,505,529	$5,241,704	$5,870,439
Trans. ore to reduc.	77,955	136,593	153,140	234,150
Reduct. ex. at Anaconda	1,362,113	2,940,175	3,640,295	4,424,278
Trans. ref. and sell.	562,600	989,562	997,939	1,721,965
Admin. expenses	23,138	59,529	53,649	57,672
Net min. profits	1,159,096	945,963	3,147,773	8,584,169
Dividends	1,200.000	2,400,000	6,300,000	6,900,000

According to the report of Pope Yeatman, the consulting engineer, the ore reserves at the end of the year were about 29,000,000 tons divided as follows: Copper Flat and Liberty, 21,000,000; Ruth, 8,000,000. The grade of this ore was approximately of the average previously developed. Up to date the only mining has been done at Copper Flat, where the extreme depth of excavation is 147 ft. below the collar of the Eureka shaft, the average being much less. This represents a depth into the orebody of about 47 ft. The Liberty orebody will be stripped and prepared for active mining during 1910. Stripping costs during 1909 averaged 43.5c. per cu.yd. Mining averaged 15.3c. per ton of ore. An additional charge of 15c. per ton of ore is made to cover stripping redemption. At the reduction works the capacity was increased from three units treating 4000 tons of ore per day, to four units treating 6000 tons. Two new McDougal furnaces were added to the 14 originally planned, the number of reverberatory furnaces was increased from two to four, and a fourth converter was added to the three orginally authorized. The works treated 1,065,387 tons of ore, averaging 2.34 per cent. copper. The percentage of extraction was 70.73. The ratio of concentration was 10.4 : 1, and the concentrates averaged 16.62 per cent. copper. The recovery of gold and silver per ton of crude ore was 23.12c. The yield of copper from ore mined and concentrated was 34,527,823 ℔. at a cost of 7.14c. per pound.

New Jersey. (By H. B. Kümmel.)—During 1909 some mining of copper ore was done at both the Pahaquarry copper mine in Warren county and at the Somerville mine north of Somerville. At the former property work was chiefly of an experimental nature, some changes in the equipment of the mill being found necessary. These included the installation of a pumping station to furnish a water supply for the mill, an ore dryer, flotation system, and the electrification of the plant.

The copper occurs as the gray sulphide, chalcocite, impregnating a hard, gray quartzite of Silurian age which outcrops on the flank of Kittatinny mountain several hundred feet above the Delaware river. Much of the chalcocite is so minutely disseminated that its presence is indistinguishable to the naked eye, owing to its close resemblance in color to the rock. It occurs also in thin seams, sometimes along the bedding or joint planes and sometimes within the mass of the rock. Less frequently the fractured surface of the quartzite shows dark-gray areas several inches or even a foot in diameter, where the chalcocite has partially replaced the rock. All available data point to the existence of a considerable body of low-grade ore, the value of which depends entirely upon the cost at which it can be milled and concentrated. Inasmuch as the proposed treatment involves untried methods, the work is in the nature of an experiment, which, in view of the large investment made, it is to be hoped will prove successful.

At the Somerville mine, controlled by the Alpha Copper Company, work continued without much interruption until late in December when operations ceased, through inability to haul coal over snow-blocked roads. Many improvements were installed during the year, including a new hoisting engine, larger cars, new dumping arrangements and additional Wilfley tables. Considerable ore was mined, concentrated and smelted, and some ingots were placed on the market. During the winter the mine was kept pumped out, and a small force of men employed in perfecting improvements. It was reported that operations would be renewed early in the spring,

New Mexico.—The production of copper in this Territory in 1909, was a little less than in 1908, but it may be expected to increase largely when the Chino Copper Company begins operations.

(By R. V. Smith.)—Developments by the Chino Copper Company, which was organized in 1909 to take over the old Santa Rita mine, are reported to show 6,000,000 tons of actual and probable ore, averaging 2.49 per cent. copper. To a large extent the orebodies can be mined by steam shovels. The experimental mill of the company treated about 135 tons of ore per day. Toward the end of 1909 the property of the Burro Mountain Copper Company was transferred to Phelps, Dodge & Co. for $2,300,000. The Chemung Copper Company operating at Tyron, claims to have developed 8,000,000 tons of positive and probable ore, averaging about 2.5 per cent. copper. The completion of the Burro

Mountain railroad will make it possible to reopen the smelting works of the Savannah Copper Company, which owns mines in the Burro mountains and at Pinos Altos, besides a smelting works at Silver City.

Tennessee.—A considerable increase in the production of this State was made in 1909. The Tennessee Copper Company and the Ducktown Iron, Copper and Sulphur Company continue to be the sole producers. Both of these concerns are now making sulphuric acid as a by-product of their smelting operations. A considerable quantity of Cuban ore is delivered to these works for smelting.

STATISTICS OF TENNESSEE COPPER COMPANY.

Items.	1906.		1907.		1908.		1909.	
	Per Ton Ore.	Per ℔. Copper.	Per Ton Ore.	Per ℔. Copper.	Per Ton Ore.	Per ℔. Copper.	Per Ton Ore.	Per ℔. Copper
Mines development	$0.1067	0.343c.	$0.1318	0.407c.	$.1193	0.393c.	$.1220	0.381c.
Mining, hoisting, etc.	0.7817	2.512c.	0.9389	2.904c.	.9019	2.968c.	1.0972	3.428c.
Crushing and sorting	0.0693	0.227c.	0.0804	0.249c.	.0702	0.231c.		
Railway	0.1389	0.438c.	0.1329	0.411c.	.0765	0.252c.	.0584	0.183c.
Blast furnace	1.4864	4.765c.	1.6219	5.016c.	1.2680	4.174c.	1.3111	4.098c.
Engineering and laboratory	0.0370	0.118c.	0.0628	0.194c.	.0504	0.166c.	.0383	0.120c.
General	0.1387	0.445c.	0.1703	0.526c.	.1486	0.489c.	.1548	0.484c.
Converting	0.2733	0.876c.	0.2402	0.743c.	.1842	0.606c.	.1469	0.459c.
	$3.0320	9.724c.	$3.3792	10.450c.	....	....	....	....
Adjustment of ore account	0.0013	0.004c.	0.0045	0.014c.	....	....	....	....
Cost of fine copper in pig	$3.0307	9.720c.	$3.3747	10.463c.	$2.8191	9.279c.	$2.9287	9.153c.
Freight, insurance and selling	....	0.68c.	....	0.68c.	....	.48c.	....	1.71c.
Taxes and all other expenses	....	0.51c.	....	0.67c.	....	.83c.	....	
Total cost per ℔. copper		10.91c.		11.79c.		10.59c.		10.86c.

Utah.—The huge increase in the production of this State in 1909 was due chiefly to the Utah Copper Company. The prospect is for progressive increases for several years to come. The United States Smelting Company expects soon to resume copper production. The Tooele smeltery of the International Smelting and Refining Company will go into operation during the summer of 1910, taking the Highland Boy ore that now goes to Garfield. In December, 1909, the Ohio Copper Company started the first section of its mill and began shipping to Garfield. In the latter part of 1909 a consolidation of the Utah Copper Company and Boston Consolidated was effected, the capital stock of the Utah Copper Company being increased for this purpose. This company is to build a new line of railway from Bingham to Garfield, and the capacity of its mills will be nearly doubled.

The Utah Copper Company in 1909 produced 51,749,233 ℔. of copper at a profit of 4.173c. per ℔. The average price received for the copper having been 12.915c., the cost of production was 8.742c. per ℔., the copper being credited with the receipts from gold and silver and all miscellaneous receipts. The amount of ore treated was 2,674,271 tons, the yield of refined copper being 19.35 lb. per ton of ore.

The Utah Consolidated Mining Company in 1909 produced 280,637 tons of ore, which yielded 10,043,900 lb. of copper, 298,167 oz. of silver and 21,569 oz. of gold. Mining cost $1.68 per ton; development, 38c.; smelting and transportation, $3.41; refining, selling and other eastern expenses, 69c.; total, $6.16. An independent examination of the mine by J. W. Finch showed that at the end of 1909 it contained 981,680 tons of well assured reserves, assaying 2.36 per cent. copper, 0.064 oz. gold and 0.959 oz. silver per ton, besides 139,680 tons of ore averaging 2.12 per cent. copper, 0.078 oz. gold and 1.209 oz. silver, indicated by the mine records, but not accessible for observation. Mr. Finch further reported that there is good probability of the discovery of new ore bodies laterally and with depth.

STATISTICS OF UTAH CONSOLIDATED.

	1904	1905	1906	1907	1908	1909
Ore treated tons	233,700	286,200	296,989	279,642	248,215	280,637
Copper, lb	13,553,483	17,264,474	18,533,974	13,987,551	10,648,243	10,043,900
per ton of ore	57.9	60.3	62.4	50.0	43.0	35.8
Silver, oz	268,880	374,685	457,812	390,296	265,283	298,167
per ton of ore	1.1	1.3	1.6	1.4	1.07	1.06
Gold, oz	23,374	28,290	42,601	34,554	23,440	21,569
Net profit	$1,179,412	$2,835,008	$1,887,385	$1,164,348	$326,312	$154,263
Mining cost	....	....	473,760	582,866	461,711	480,036
Exploration and development	....	....	84,864	107,155	73,441	108,850
Smelting cost	....	....	747,717	867,087	902,266	982,392
Custom ore purchases	....	....	274,032	131,796	*Nil.*	*Nil.*
Refining charges, freight, marketing, etc.	....	....	267,921	227,152	141,401	158,137
Miscellaneous	....	....	70,773	70,754	150,410	41,123
Total costs	(*a*)1,295,626	(*a*)1,590,881	1,919,067	1,986,810	1,729,229	1,770,538

(*a*) Costs not segregated in report.

Wyoming.—Production in 1909 was insignificant, the Penn-Wyoming having been idle. Plans were on foot to operate again in 1910, but litigation has arisen among the promoters and stockholders of this company, which may delay exploitation of the mine.

Copper Mining in Foreign Countries.

Australasia.—There was a rather large decrease in the copper production of this group of colonies in 1909.

(By F. S. Mance.)—The production of the Mount Lyell company, Tasmania, in 1909 was slightly larger than in 1908, due chiefly to a little improvement in the grade of the ore mined. The cost of producing blister copper for the year ending with September was $3.69 per ton of ore treated. In South Australia, Wallaroo & Moonta suffered from the low price for the metal, which reduced the supply of outside ore, and owing to a shortage of coal because of the colliery strike in New South Wales, smelting operations were suspended from November to the end of the year. The copper production in 1909 was 5295 tons, the amount of ore smelted being 52,574 tons. The cost of producing copper f.o.b. ship in 1908 was £54 16s. 8d. per ton; in 1909 it was £53 3s. 11d.

The copper production of Queensland in 1909 was 14,494 tons, against

WALLAROO & MOONTA STATISTICS.

	1904	1905	1906	1907	1908	1909
Ore from Wallaroo mines, tons	21,766	35,189	43,241	53,571	40,383	41,397
Ore from Moonta mines, tons	10,686	8,161	10,360	16,397	10,913	9,879
Precipitate, tons	494	930	957	833	813	671
Outside ores and matte, tons	5,381	5,151	3,520	4,865	1,439	627
Ore smelted, tons	38,995	49,961	58,068	75,666	58,009	52,574
Copper produced, tons	5,835	6,501	7,561	8,627	6,448	5,295
Silver to mint, oz	7,147	4,781	3,614	5,845	7,416	4,995
Gold to mint, oz	1,260	1,646	1,643	2,009	1,950	1,819
Sulphuric acid delivered, tons	3,433	5,312	5,112	5,379	4,953	4,758
Bluestone made, tons	181	340	328	224	201	299

14,698 tons in 1908. At the Mount Morgan company's property serious falls of roof which occurred in September and November, 1908, checked operations with the result that several of the furnaces had to be put out of commission. Operations, subsequently proceeded on an increased scale, and the company contributed an output of 6270 tons in 1909.

In New South Wales the principal copper producing mines were the Great Cobar, the Grafton and the Kyloe. The output of copper for the year was 6966 tons. The Great Cobar, Ltd., at the outset experienced some difficulty in operating the new furnaces installed, and labor troubles caused a suspension of work during the closing weeks of the year. The blister copper produced during 1909 by this company was estimated to contain 4855 tons of copper. The Port Kembla works of the Electrolytic Refining and Smelting Company of Australia, Ltd., was in operation for practically the whole year. This company deals with the whole of the output of blister copper from the Mount Morgan mine. The smelting department drew supplies of matte and ore from all parts of Australia. The production in 1909 was 5851 tons of electrolytic copper.

Canada.—The production of copper in Canada in 1909 was 47,677,361 lb., against 53,725,213 lb. in 1908. As heretofore, the Boundary district of British Columbia and the Sudbury district of Ontario were the largest producers. The British Columbia and Granby companies were the only ones producing blister copper. The remainder of the Canadian production was exported as ore and matte, chiefly the latter, the bulk of this material being sent to the United States for smelting. About 1,500,000 lb. of the decrease in the Canadian output was due to the suspension of production at the Le Roi mine at Rossland.

(By E. Jacobs.)—In the Boundary district the Granby company's mines led with an output of 21,901,528 lb. of copper. This company completed improvements to its smelting plant which now has a maximum capacity of 4500 tons of ore per day. The production of the British Columbia Copper Company was interrupted for a period of three months, from May to August, on account of a strike of the coal miners of the Crows' Nest Pass district, from which the fuel supply is obtained. During the nine months' operation, the mines at Greenwood produced 367,024 tons of ore. This, together with a small tonnage of custom ore amounted to 373,336 tons smelted. Blister copper to the amount of 6,366,318 lb. was recovered, containing fine copper, 6,325,000 lb.; gold, 18,244 oz.; and silver, 64,234 oz. The yield of copper per ton of ore was 17.7 lb.; gold and silver amounted to $1.03 per ton. The cost of production after crediting expenditure with gold and silver contents was 9.829c. The cost per ton of ore handled was $2.683. Enlargement of two of the three 700-ton blast furnaces of the company is to be made to provide for ore from a mine the company has opened in Wellington camp, and also for ore from the New Dominion Copper Company's mines, which it is stated will be treated here. The Consolidated company's Snowshoe mine, with an output of 3,775,000 lb., made a gain of about 2,500,000 lb. over the production of 1908. The Dominion Copper Company's mines were not operated during 1909, and there does not appear to be any probability of the company's smelting works at Boundary Falls being used again under existing conditions.

At Rossland, the Le Roi mine was not in operation, and there was a small decrease in the production of the Center Star and the Le Roi No. 2 Company's Josie mine. The Tyee Copper Company installed a second blast furnace at its works at Ladysmith, Vancouver Island. There was no production of copper ore on Vancouver Island in 1909 worth mentioning, but the Tyee Copper Company kept its works operating on ores from other districts. Exploration work was continued at the Britannia mine on Howe sound, and latterly, about 100 men were employed at the mine and mill. A shipment of about 11,000 tons of second-grade ore from the Marble Bay mine, Texada Island, returned 4 per cent. copper. A neighboring mine, the Cornell, reported 6.2 per cent. from 11,000 tons of ore.

Chile.—The production of copper in Chile in 1909 amounted to 42,726 metric tons as compared with 42,097 metric tons in 1908. The Braden Copper Company, the most important operation in which American capital is interested, increased the capacity of its mill from 250 to 400 tons daily. A new mill of 1600 tons' daily capacity is being constructed and will be completed in 1911. Construction was continued on the railroad which the company is building from Rancagua to the mines, and the entire line will probably be ready for operation during 1910. The company reports as developed 5,000,000 tons of ore averaging 2.7 per cent. copper.

A French company has been developing the blanket copper deposit at Naltagua. Its principal mines, the San Ramon, Vacas, and Buitres, collectively make an estimated daily output of 350 tons of ore averaging 4 per cent. copper. The mines have been worked about two years and at present employ over 600 men. The company has built a smeltery and on April 15, 1909, blew in its furnaces which have a capacity of 350 tons of charge daily. A narrow-gage railway 14 km. long has been constructed between the different mines, and a 5600-m. cableway has been built to connect the terminus of this road with El Monte station on the railroad from Santiago to Melpilla.

China. (By T. T. Read.)—China is an important producer of copper, but as the industry is a government monopoly there is no way of obtaining definite information as to the amount of annual production, and it is almost equally impossible to make any estimate of it. The best accounts of the producing districts are those of Rocher in the *Compte rendu de la Mission Lyonnais,* and of Leclère in his *Étude Geologique et Minière des Provinces Chinoises Voisines du Tonkin.*

Katanga.—Development work was carried on steadily during 1909. The section of the Rhodesia-Katanga railway from Broken Hill to the Congo border, 131 miles, was completed Nov. 16, and opened for traffic on Dec. 11, 1909. The Belgian section, 160 miles, from the border to the Star of the Congo mines, is expected to be completed by Oct., 1910. From the Star of the Congo, the next section of the railway will be to Kambove, 110 miles to the north, and thence to Bukana on the navigable headwaters of the Congo, a distance of about 100 miles. The principal copper mines in Congo territory are the Star of the Congo and the Kambove, and in Rhodesia, the Kansanshi. At the latter mine over 1000 tons of copper bars are awaiting the arrival of the railroad, and the small furnace producing 80 tons per month is being enlarged.

The great copper resources of the Tanganyika Concessions Company are in the Congo country. According to Allan Gibb, the head engineer, there is ore containing 200,000 tons of copper in sight at the Star of Congo and Kambove mines, with a probability of a further 200,000 tons. The smelting works proposed for the Star will give an output of 12,000 tons of copper per annum, and it is estimated that there is sufficient smelting ore at this mine, and at the Kambove, to last 30 years at this rate of production. Besides the smelting ore, there is a great quantity of silicious rock, which it is claimed can be profitably treated when it contains more than 4 per cent. copper. A mill of 2500 tons daily capacity has been ordered by the Union Minière du Haut Katanga to treat this ore. With both smelting and silicious ore, an output of 30,000 tons of metallic copper per annum is considered probable. While it is recognized that the Katanga region possesses large copper resources, it will probably be several years before this copper begins to figure prominently in the market.

Mexico.—The copper production of Mexico in 1909 was 126,169,962 lb., as compared with 89,576,464 lb. in 1908. The largest part of the increase in the output was due to the resumption of production on a large scale at Cananea. During 1909 the Mexican government granted the Cananea company the right to import oil free. This concession, together with new installations for ore treatment and improved methods of mining have placed the production of the company on a greatly reduced cost basis, The Boleo mine, in Baja California, owned by the French Rothschilds, continued to work at full capacity, shipping its product to France. The copper smeltery at Teziutlan, was not in operation during 1909, but went into commission early in 1910. The Continental mine at Panuco was idle during 1909, pending investigation as to a special process for treating its ores. The Mazapil Copper Company, operating in the northern part of Zacatecas, and with a smeltery at Mazapil, continued to produce to normal capacity. In Sonora, the Moctezuma Copper Company of Phelps, Dodge & Co., made the largest output in its history, shipping its product to the Copper Queen smeltery at Douglas, Arizona. In 1909 this company produced 517,927 tons of ore, of which 510,094 tons, averaging 3.22 per cent. copper, were concentrated. The average grade of concentrate was 11.8 per cent. copper; ratio of concentration 4.61 : 1; yield, 2.56 per cent.; average assay of tailings, 0.584 per cent.

MOCTEZUMA COPPER COMPANY.

Year.	Pounds Copper.	Net Earnings.
1903	10,281,970	$456,524.55
1904	11,061,049	598,992.36
1905	10,160,016	533,117.66
1906	12,714,726	1,195,424.18
1907	9,640,390	833,236.25
1908	15,522,580	524,902.00
1909	26,487,776	1,104,454.00

RIO TINTO STATISTICS.

	Pyrites Extracted.				Pyrites Consumed.		Copper Produced at Mines.
Year.	For Shipment.	For local treatment.	Total.	Average Copper contents.	Tons 2240 lb.	Average Copper contents.	Tons 2240 lb.
				p.c.			
1876	189,962	159,196	349,158	1.5	158,597	1.5	946
1877	251,360	520,391	771,751	2.375	211,487	2.	2,495
1878	218,818	652,289	871,107	2.78	211,403	2.18	4,184
1879	243,241	663,359	906,600	2.78	236,849	2.45	7,179
1880	277,590	637,567	915,157	2.865	274,210	2.481	8,559
1881	249,098	743,949	993,047	2.75	256,827	2.347	9,466
1882	259,924	688,307	948,231	2.805	272,826	2.401	9,740
1883	313,291	786,682	1,099,973	2.956	288,104	2.387	12,295
1884	312,028	1,057,890	1,369,918	3.234	314,751	2.241	12,668
1885	406,772	944,694	1,351,466	3.102	354,501	2.270	14,593
1886	336,548	1,041,833	1,378,381	3.046	347,024	2.306	15,863
1887	362,796	819,642	1,182,438	3.047	385,842	2.283	17,813
1888	434,316	969,317	1,403,633	2.949	393,149	2.208	18,522
1889	389,943	824,380	1,214,323	2.854	395,081	2.595	18,708
1890	396,349	865,405	1,261,754	2.883	397,875	2.595	19,183
1891	464,027	972,060	1,436,087	2.649	432,532	2.651 1.309	21,227
1892	406,912	995,151	1,402,063	2.819	435,758	2.569 1.465	20,017
1893	477,656	854,346	1,332,002	2.996	469,339	2 659 1.544	20,887
1894	498,540	888,555	1,387,095	3.027	485,441	2.594 .988	20,606
1895	525,195	847,181	1,372,376	2.821	518,560	2.595 .986	20,762
1896	591,752	845,580	1,437,332	2.931	549,585	2.529 1.068	20,817
1897	575,733	812,293	1,388,026	2.810	582,540	2.595 .967	20,826
1898	644,518	820,862	1,465,380	2.852	618,110	2.600 1.023	20,426
1899	644,271	1,005,573	1,649,844	2.719	636,323	2.511 1.120	20,230
1900	704,803	1,189,701	1,894,504	2.744	665,967	2.553 1.187	21,120
1901	633,949	1,294,827	1,928,776	2.627	641,935	2.680 1.025	21,100
1902	627,967	1,237,322	1,865,289	2.517	595,092	2.342 1.495	21,659
1903	688,919	1,229,619	1,918,538	2.390	667,748	2.320 1.241	21,565
1904	672,344	1,276,475	1,948,819	2.340	663,744	2.105 .978	21,218
1905	627,336	1,202,768	1,830,104	2.363	660,724	2.182 1.124	19,530
1906	655,328	1,268,388	1,923,716	2.411	632,307	2.302 1.198	21,287
1907	641,858	1,265,090	1,906,948	2.417	607,944	2.112 1.048	21,251
1908	604,275	1,115,610	1,719,885	2.265	589,815	2.037 .952	24,256
1909	604,799	1,184,188	1,788,987	2.349	600,946	1.832 2.058	24.364

The custom smelteries at San Luis Potosi, Chihuahua, Aguascalientes, Monterey and Torreon, treated ores from the smaller mines operating in tributary sections. In Guerrero an important property is being opened up at La Union. The copper deposits of Michoacan were in the main idle during 1909. The property belonging to the Rothschilds at Inguaran has been extensively developed, and is said to have blocked out several million dolars worth of ore running from 2 to 4 per cent. copper; but it is impracticable to operate without a railroad. Several smaller properties in this State have been developed in a small way and there is promise of extensive copper production when transportation conditions are improved.

Peru.—The Cerro de Pasco company continues to be the most important copper producer in Peru. At present its output is at the rate of 40,000,000 ℔. per annum, which is shipped to the United States for refining. The smeltery is running successfully, and the company is utilizing coal from the local fields as far as possible. The cost of production is reported at the remarkably low figure of 6c. per ℔. A hydro-electric plant is being installed.

Spain.—The Rio Tinto Company, Ltd., in 1909, mined 1,788,987 tons of ore, with an average content of 2.349 per cent. The copper produced by treatment at the mine was 24,364 tons, and that in the pyrite shipped was 11,008 tons. Details of the production of this company since 1875 are given in the accompanying table:

PRODUCTION OF COPPER IN RUSSIA.
(In poods. 1 pood =16.381 kg. =36.114 ℔.)

Years.	Ural.	Caucasus.	Siberia.	Kirghiz Steppe	Altai.	Finland.	Various.	Total.
1895	151,511	166,728	....	1,394	15,888	21,858	....	357,379
1896	167,574	149,698	....	1,868	13,239	23,640	....	356,019
1897	220,783	162,534	....	3,586	15,427	21,360	....	423,690
1898	236,863	173,993	....	2,440	16,341	15,445	....	445,082
1899	253,610	171,568	....	5,754	15,292	13,664	....	459,888
1900	241,148	227,079	....	11,273	11,322	13,354	....	504,176
1901	217,063	247,348	....	21,993	13,193	17,311	....	516,908
1902	279,135	213,273	....	25,238	7,431	13,231	....	538,308
1903	265,116	262,919	....	17,902	7,546	10,126	....	563,609
1904	265,915	296,666	....	30,513	7,344	....	....	600,438
1905	225,800	223,800	67,000	....	....	....	53,900	570,500
1906	288,600	232,300	40,500	....	....	....	74,700	636,100
1907	457,904	310,244	68,957	....	....	....	65,253	902,358
1908	522,584	296,379	155,116	....	....	....	54,616	1,028,695
1909	530,778	391,200	150,582	....	2.940	....	57,984	1,126,584

Outside of the Rio Tinto Company, the largest producers were the Tharsis Sulphur and Copper Company, the United Alkali Company, Esperanza, Huelva, Compañia de Minerales de Huelva, Peña, and San Pedro. According to the *Revista Minera,* exports of copper from Spain during 1909 were as follows: Copper, 17,745 metric tons, copper precipitate, 16,842 metric tons, and copper ore, 1,087,060 metric tons.

Russia.—The production of copper in Russia during 1909 amounted to 1,126,584 poods, or 18,065 long tons, an increase of 97,889 poods over the output of the preceding year. The increase is to be attributed almost entirely to the copper smelteries in the Caucasus as reference to the accompanying table clearly shows.

Work in the Altai district was carried on with frequent interruptions, and the production continues to fluctuate between considerable limits. Two copper smelteries were at work in Siberia—the Spassky, at Akmolinsk, and the Yuli, at Minusinsk. According to the Tomsk mining district reports, the quantity of bar copper produced at the Spassky works in 1909, was 106,286 poods against 97,546 poods in 1908; and at the Yuli works 40,073 poods against 50,528 poods. Besides the foregoing the Dzhiltav electrolytic refinery (Warter & Co.), in the Karkuralinsk district of Sempalatinsk has been at work since Oct. 14, 1908, up to the end of which year it produced 2247 poods, followed by 3857 poods in 1909. In the Urals there was a marked decrease in the output of the smeltery of the Demidoff successors. In South Russia the Caucasus Copper Company, with mines at Dzansul abandoned its magnetic process of concentration and installed a wet concentrating plant with a daily capacity of 250 tons. Results were so satisfactory that another unit of 250 tons is being installed.

The Copper Markets in 1909.

New York.—At the beginning of 1909 there was a hopeful feeling in the copper market which, however, was destined to early disappointment, because of the gradual conviction that the surplus in the hands of American refiners at the end of 1908 was materially larger than was generally supposed. Throughout 1909 the market was in a sensitive condition, being always under the influence of the speculative market in London. Much has been said to deprecate the influence which the London standard market has been exercising on the business in the refined metal. It is, however, but reasonable to conclude that through the London market it has been made possible to distribute among many the burden of carrying the large stock which might have brought about unpleasant conditions if it had been left in a few hands.

In the early days of January electrolytic copper was quoted at 14¼@14⅜c., but later in the month the price receded under rather urgent selling. Throughout February the market was dull and saggy, sales being unusually small because manufacturers had overbought themselves in previous months, and prices continued to decline. During the last week of this month, a basis of 12⅜c. was reached. This interested European buyers, and some fairly large sales, continuing into March, were consummated.

Although prices did not improve much in April, business was in good volume, and the market held its own at 12½@12⅝c. During May the demand from manufacturers improved very much, and there was a steady advance in the price for electrolytic to about $13\frac{1}{4}$c. In June an outburst of speculative buying in all the European markets advanced the price to $13\frac{1}{2}$c., but later on speculative selling precipitated a decline to 13 cents.

In July the market receded further, but at $12\frac{3}{4}$c. a large buying movement developed, and the month closed at $12\frac{7}{8}$c. About the middle of August excited buying from European sources and a considerable demand from domestic manufacturers advanced the price to about $13\frac{1}{8}$c., the month closing at 13c. During September the market declined a trifle further.

The chief feature in October was the stiffening in the money market, which compelled some speculators to liquidate. At $12\frac{1}{2}$c. a better demand from manufacturers began, and this carried prices up to about $12\frac{3}{4}$c. During the early part of November the improvement was helped by the speculative movement arising from the talk of a copper consolidation. The volume of business up to Nov. 20, was on a larger scale than at any other time during 1909, the price rising to $13\frac{5}{8}$c., but this speculative movement was checked by the Standard Oil decision, and under the influence of heavy liquidation at London, prices gave way sharply, the month closing at about $13\frac{1}{8}$c. There was a recovery in December, the tone of the market being steady throughout the month, and the market closed at about $13\frac{5}{8}$ cents.

AVERAGE PRICE OF LAKE COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1900	16.33	16.08	16.55	16.94	16.55	16.00	16.16	16.58	16.69	16.64	16.80	16.88	16.52
1901	16.77	16.90	16.94	16.94	16.94	16.90	16.51	16.50	16.52	16.60	16.60	14.39	16.55
1902	11.322	12.378	12.188	11.986	12.226	12.360	11.923	11.649	11.760	11.722	11.533	11.599	11.887
1903	12.361	12.901	14.752	14.642	14.618	14.212	13.341	13.159	13.345	12.954	12.813	12.084	13.417
1904	12.533	12.245	12.551	13.120	13.000	12.399	01.505	12.468	12.620	13.118	14.456	14.849	12.990
1905	15.128	15.136	15.250	15.045	14.820	14.813	15.005	15.725	15.978	16.332	16.758	18.398	15.699
1906	18.419	18.116	18.641	18.688	18.724	18.719	18.585	18.706	19.328	21.722	22.398	23.350	19.616
1907	24.825	25.236	25.560	25.260	25.072	24.140	21.923	19.255	16.047	13.551	13.870	13.393	20.661
1908	13.901	13.098	12.875	12.928	12.788	12.877	12.933	13.639	13.600	13.646	14.386	14.411	13.424
1909	14.280	13.295	12.826	12.938	13.238	13.548	13.363	13.296	13.210	13.030	13.354	13.647	13.335

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1900	15.58	15.78	16.29	16.76	16.34	15.75	15.97	16.35	16.44	16.37	16.40	16.31	16.19
1901	16.25	16.38	16.42	16.43	16.41	16.38	16.31	16.25	16.25	16.25	16.22	13.82	16.11
1902	11.053	12.173	11.882	11.618	11.851	12.110	11.771	11.404	11.480	11.449	11.288	11.430	11.626
1903	12.159	12.778	14.416	14.454	14.435	13.942	13.094	12.962	13.205	12.801	12.617	11.952	13.235
1904	12.410	12.063	12.299	12.923	12.758	12.269	12.380	12.343	12.495	12.993	14.284	14.661	12.823
1905	15.008	15.008	15.125	14.920	14.627	14.673	14.888	15.664	15.965	16.279	16.599	18.328	15.590
1906	18.310	17.869	18.361	18.375	18.457	18.442	18.190	18.380	19.033	21.203	21.833	22.885	19.278
1907	24.404	24.869	25.065	24.224	24.048	22.665	21.130	18.356	15.565	13.169	13.391	13.163	20.004
1908	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.208
1909	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982

London.—Early in January an active business was done with consumers, but a persistent decline in price continued through the month, the opening price for cash standard having been £63⅝, while the closing was £58¼. This condition continued during February, the price for standard on the 26th being £55⅞. A litle recovery took place in March, for which month the closing price was £57.

In April the market fluctuated under speculative influences. The actual improvement in trade in Europe was insignificant, and more particularly in Great Britain where consumers remained reserved. In May, however, the consuming industries showed some signs of revival, especially in electrical work in Germany, while there was also an improved demand from British engineers and shipbuilders and substantial orders from India. The month closed at £60⅞ for cash standard. During June there was great activity in the market, the speculative interest broadening, while trade orders were on a larger scale than for a long time previously. The activity did not, however, continue long.

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'s) IN LONDON.
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901	71.78	71.17	69.54	69.61	69.60	68.83	67.60	66.34	65.97	64.11	64.51	52.34	66.79
1902	48.43	55.16	53.39	52.79	54.03	53.93	52.89	51.96	52.68	52.18	51.03	50.95	52.46
1903	53.52	57.34	63.85	61.72	61.73	57.30	56.64	58.44	56.82	55.60	56.30	56.36	57.97
1904	57.500	56.500	57.321	58.247	57.321	56.398	57.256	59.952	57.645	60.012	65.085	66.375	58.884
1905	68.262	67.963	68.174	67.017	64.875	65.881	66.887	69.830	69.667	71.406	74.727	78.993	69.465
1906	78.869	78.147	81.111	84.793	84.867	83.994	81.167	83.864	87.831	97.269	100.270	105.226	87.282
1907	106.739	107.356	106.594	98.625	102.375	97.272	95.016	79.679	68.375	60.717	61.226	60.113	87.007
1908	62.386	58.786	58.761	58.331	57.387	57.842	57.989	60.500	60.338	60.139	63.417	62.943	59.902
1909	57.688	61.198	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732

During July the business was dull, consumers became distrustful, and several tired speculators liquidated their commitments. In August the European trade was disappointingly dull. The closing price for the month was £59¾ for cash warrants. In September the market was greatly disturbed by the increase in the visible supply, but after some considerable fluctuations the month closed at £59$\frac{5}{16}$ for cash standard. A further increase in the visible supply reported at the beginning of October again discouraged buyers, but upon a reduction in quotations some fair trade orders came out. The month closed at £57$\frac{9}{16}$ for cash warrants. November was an eventful month, reflecting American conditions. The closing price was £58⅝ for cash warrants. December started with a weak market in the absence of active speculation, but a further decline was arrested by encouraging news from America and an improved demand from European consumers. A revival in the electrical trade in Germany contributed to the general improvement.

The Metallurgy of Copper in 1909.

By L. S. Austin.

Reverberatory Smelting.

Reverberatory Practice at Cananea, Mexico.[1]—The furnace plant, of which Fig. 1 shows a plan and various sections, has been in regular operation upon the flue dust from the blast furnaces and calcines from first-class concentrates, since September, 1908. The furnace has a hearth, 19x100 ft., with side walls 31 in. thick and a roof of 15 in., these parts, together with the outlet flue, being of silica brick. This flue leads to three 300-h.p. Stirling boilers set in parallel to receive the furnace gases. The neck of the furnace has an area of 27 sq. ft., but Dr. Ricketts thinks this is too small.[2] A stack 116½ ft. high and 8 ft. in diameter furnishes the draft. Fig. 2 illustrates Gmehling's method of repairing, fettling or claying the furnace to protect the side walls from the corrosive action of the molten charge. The walls are built with a slight batter as shown in the cross-section. At intervals of 18 in. along the arch and immediately above the side walls, there are 5x5-in. ports. A traveling hopper on either side of the furnace delivers fettling material of dampened, fine, silicious ore to any one of these ports. Every day material is introduced through these holes wherever it appears to be needed. It drops down by the side walls and builds up as a bank against the slag. The fettle is then gently tamped with an iron bar. Each port is kept closed by a brick laid across it. From 10 to 15 tons of silicious ore are thus used daily, the gold and copper contained, eventually finding their way into the matte without the extra expense of smelting.

The furnace is charged from the three hoppers nearer the fire end, and is heated by four Shelby oil burners which have been found to be of the most satisfactory type for this work. The four openings in the back wall for the burners are 15 in. in diameter. Air ports, 10 in. in diameter, are also provided. Fig. 3 is a sectional elevation and rear view of the burner. The oil, under a pressure of 40 ℔. per sq.in., enters the annular chamber through the ½-in. pipe marked "oil supply," and escapes through the ⅞-in. opening of the nozzle. The steam enters by a ½-in. pipe, and escapes, through an annular aperture of 1/64-in. opening, to the nozzle where it comes in contact with the film of oil issuing from the annular chamber. The steam forces the oil into the furnace at a high velocity, at the same time completely atomizing it. By operating

---

[1] *Min. World*, XXXI, 1115; Dr. L. D. Ricketts, *Trans.*, I. M. M., 1909. *Eng. and Min. Journ.*, LXXXIX, 31 314-318.

[2] Practice at Anaconda, where the volume of escaping gases is greater, indicates the contrary—that with too large a neck, too much heat is lost.

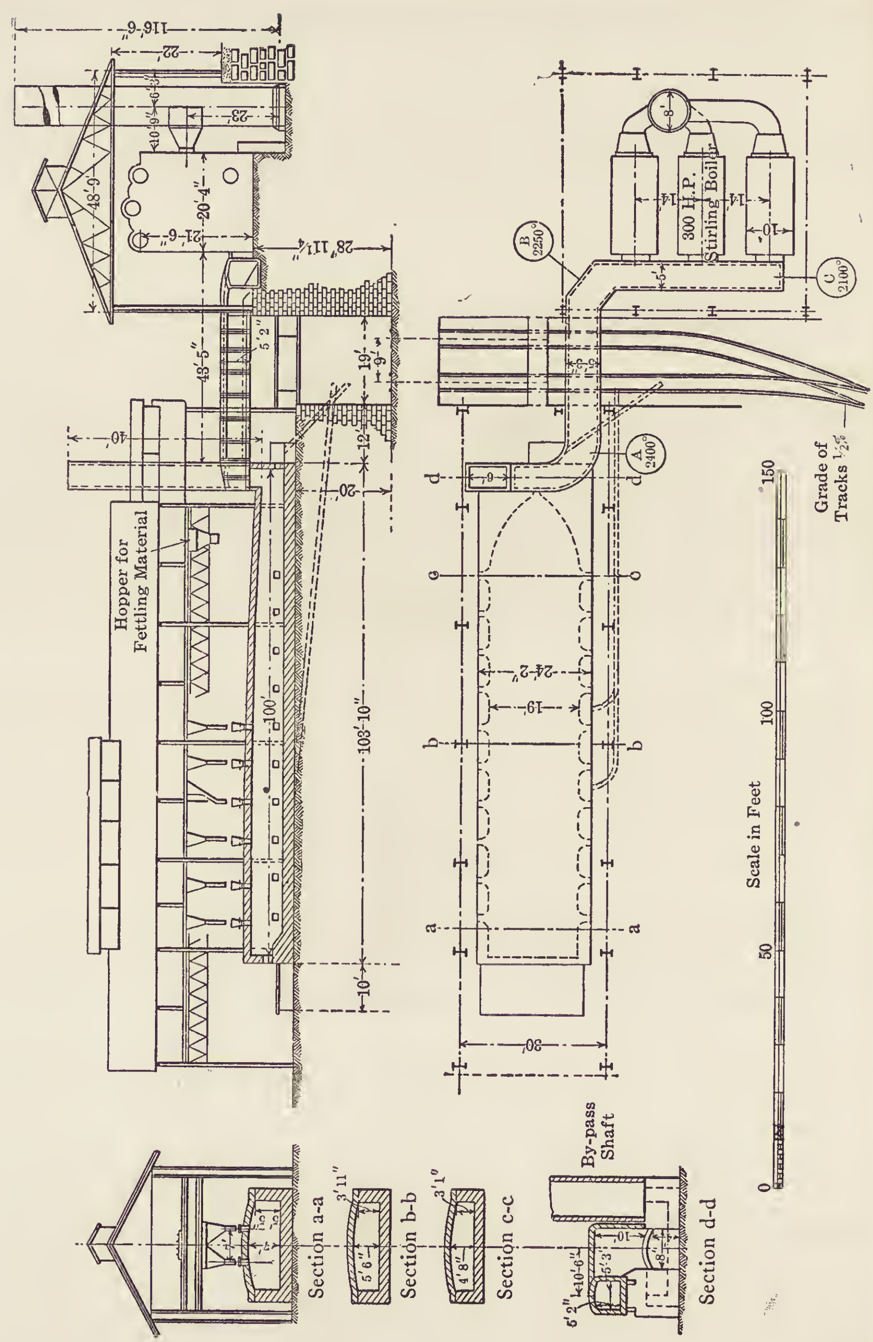


FIG. 1.—ORIGINAL REVERBERATORY OF CANANEA CONSOLIDATED COPPER COMPANY.

the central steel pin or plug by means of the hand-wheel, the supply of oil or of steam can be controlled. When consuming 50 to 60 tons of oil in 24 hours, 0.36 lb. of steam is needed per pound of oil. To smelt 250 to 275 tons of charge per day, 235 bbl., or 35 tons, of petroleum residuum are required. This residuum, coming from Oklahoma, has a specific gravity of 0.9 (a barrel of 42 gal. weighs 310 lb.), and a heating value of 10,830 calories. The temperature of the escaping gases at *A*, Fig. 1, is 1316 deg. C.; at *B*, in the flue, 1235 deg. C.; and at *C*, the entrance

RESULTS OF REVERBERATORY FURNACE RUNS AT CANANEA.

Run.		For 5 Months in 1908.	For 6 months in 1909.	For Jan., 1909.
Charge	Flue dust, tons	19,737	29,802	4,639
	Calcines, tons	9,554	5,484	2,711
	Silicious ore, tons	1,192	2,300	395
	Iron and limestone, tons	574	3,129	440
	Barren silica, tons	274	....	....
Total		31,331	40,715	8,140
Product	Matte, tons	7,039	10,120	....
	Slag, tons	20,351	25,658	....
	Volatilized, tons	3,941	4,937	....
Total		31,331	40,715	....
Actual running time, days		150	165.7	31
Charge smelted daily, tons		209	245	263
Content of charge	Cu per cent	8.4	7.	7.1
	S per cent	9.0	9.8	7.5
Cu content of matte, per cent		36.0	30.6	40.0
Cu recovered, per cent		95.7	96.0	96.0
Composition of slag	Cu per cent	0.55	0.45	0.41
	SiO_2, per cent	39.2	40.1	41.2
	Al_2O_3, per cent	10.1	11.2	11.0
	FeO, per cent	40.0	34.8	34.6
	CaO, per cent	4.3	8.5	7.3
Total per cent		94.15	95.05	94.51

to the boilers, 1150 deg. C. In the case of the oil-burning furnace the temperature at the neck is therefore unnecessarily high. The temperature of the gases leaving the boilers is 400 deg. C. About 40 per cent. of the total heat evolved is in the escaping gases and, as computed by the above data, one-eighth of this is lost by radiation in the long flue connecting the furnace to the boilers. The high temperature developed by the oil fuel is shown by the fact that the silica-brick roof has been burned out three times.[2]

The accompanying table gives the results of three furnace runs, the first from Sept. 1, 1908, for five months; the second for six months from Jan. 1, 1909; and the third for the month of January, 1909.

The total direct costs for the three runs, including labor, shop expense, supplies, fuel oil, power, and miscellaneous expense were, respectively,

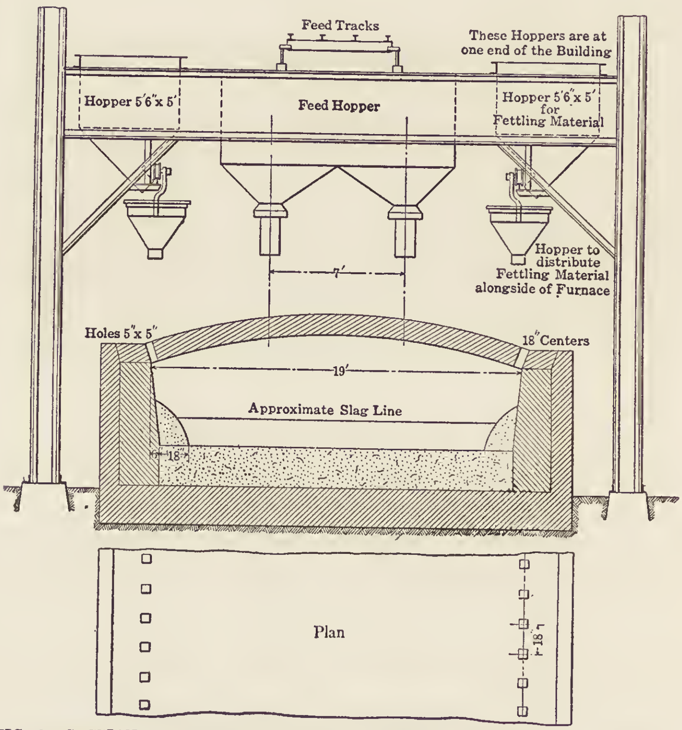


FIG. 2.—SECTION OF FURNACE, CANANEA CONSOLIDATED COPPER COMPANY, SHOWING METHOD OF CHARGING AND CLAYING.

$2.56, $2.45, and $1.96 per dry ton smelted. The evaporation per pound of oil burned under the power-house boilers was 16.08 lb. of water from and at 212 deg. F., and per pound of oil burned under the waste-heat boilers, 7.45 lb. or 46.3 per cent. of the evaporation at the power-house boilers. This proportion of the total cost of the oil is, therefore, credited to steam production by the reverberatory system and is deducted

[1] From the data given, the writer would propose an increase of 25 to 50 ft. in the length of the furnace at the back or fire end, and the raising of the roof in the region of highest heat. If this were done more heat would be absorbed in melting the charge and the escaping gases would then come nearer to the melting temperature of the charge, viz., 1100 to 1150 deg. C. Most of the melting should be done near the fire end. Oil burning might be supplemented by a regulated supply of air under pressure, thus decreasing the suction of cold air into the furnace.

from the total direct costs, leaving the net costs per dry ton $1.78, $1.76 and $1.29, respectively. When coal was used as fuel, costs were so high as to be prohibitive, but with oil, results show a maximum net cost of $1.78 per dry ton, with a probable average figure of $1.40 per ton under favorable conditions.

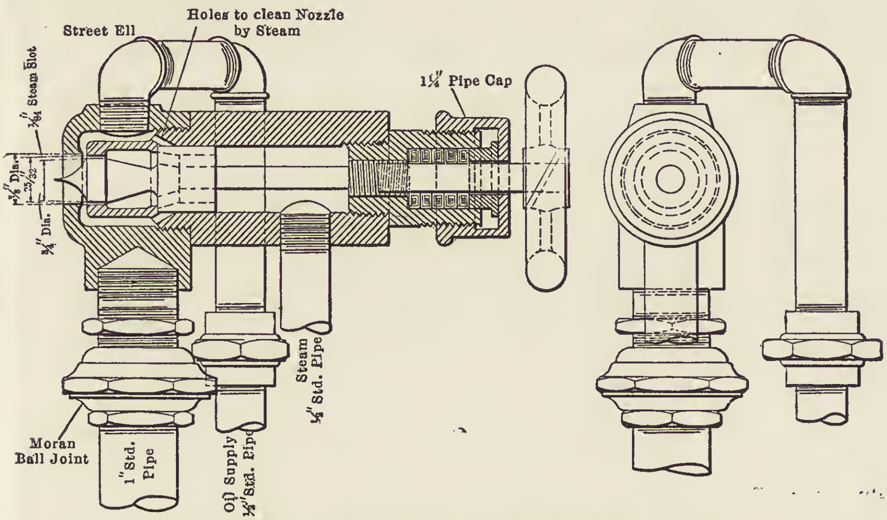


FIG. 3.—SHELBY OIL BURNER FOR REVERBERATORY FURNACE, CANANEA CONSOLIDATED COPPER COMPANY.

Blast-Furnace Smelting.

Blast-Furnace Practice at Cerro de Pasco.—R. L. Lloyd describes[1] the requirements for successful operation at this plant, situated at an elevation of 14,000 ft. where the barometric pressure, and hence the density of the air, is only 60 per cent. of that at the sea level. There are three copper-matting blast funaces, 56x180 in. each, with an 8-in. bosh and capable of carrying a 14-ft. smelting column. The ore is a sulphide consisting of pyrite, chalcopyite and pyrrhotite. It contains a little lead and zinc, and a fair quantity of silica. The ore is supplied to the furnaces in favorable mechanical condition and is run with a limestone flux and a coke containing 54 per cent. ash.

Owing to defective methods, the furnace runs were at first unsuccessful, but Mr. Lloyd obtained satisfactory results by operating as follows: A wood fire was built upon the hearth and coke charged upon it until a foot above the tuyeres. When this had become a glowing fire throughout, 12 charges of fusible slag with the proper proportion of coke were added, followed by 10 charges of one-half slag and one-half normal

[1] *Min. World*, XXXI, 639; *The Mineral Industry*, XVII 262.

charge, also with the proper percentage of coke. The normal charge was then added until the furnace was filled to the stock line 10 ft. above the tuyeres. The charge weighed 2200 lb. The tuyere-caps were next put on, leaving only the 1½-in. poke-holes open, and the furnace was allowed to stand for four hours. A gradually increasing blast was now turned on and slag began to fill the settler. When this was filled and the furnace became tighter the blast was increased until in 24 hours the furnace was running normally with a blast pressure of 24 oz. per square inch.

To arrive at the percentage of fuel needed the fixed carbon content of the coke was compared with that of a Connellsville coke with 11 per cent. ash. This gave a fuel ratio of 41 to 85, or a little more than one to two. A fusible slag was chosen and computed for the ore, limestone and coke ash. A "pack" was obtained in the furnace by breaking the larger lumps of coke and limestone to smaller size and by charging the coarse material to the center and the fines to the sides. The items of the charge were loaded in an order calculated to accomplish this result.

High-Silica Slags.[1]—The Magistral smeltery, Zacatecas, Mex., was designed by C. A. Heberlein for the treatment of silicious ores low in copper. The furnace is 46x150 in. at the tuyeres with water jackets 9 ft. high and having 16 tuyere openings. The forehearth is 9 ft. long, 4 ft. wide, and 2 ft. deep. An ordinary cast-iron tap-jacket is used for intermittent tapping. The gases from the furnace escape by a steel uptake to a stack 103 ft. high.

During a run of 17 days, using a charge of copper ore, iron ore, limestone and 8.1 per cent. of low-ash Pocahontas coke, a bisilicate slag with SiO_2, 49.8 per cent.; FeO, 23.1; CaO, 21.3; Al_2O_3, 4.5; MgO, 0.5; ZnO, 1; and Cu 0.22 was successfully made, using 190 tons of charge daily and producing a matte containing 30 per cent. Cu. The charge contained 7.5 per cent. S and gave a matte-fall of 5.5 to 5.8 per cent. This indicates a volatilization of 81 to 82 per cent. of the sulphur. The slag from the slag pots strings out into filaments, sometimes 3 ft. in length, but the slag shells are generally as thin as paper and never exceed ½ in. in thickness.[2] The smelting column is from 8 to 9 ft. high and the furnace is run with a concentrated and well-controlled smelting focus and with but little over-fire. Under these conditions the slag leaving the furnace is extremely hot and perfectly liquid.

[1] *Eng. and Min. Journ.*, LXXXVIII, 107, 177.

[2] Mr. Heberlein does not agree with Mr. Shelby (*Eng. and Min. Journ.*, LXXXVI, 270), who says, "Alumina is neither a base nor a foreign substance carried into a slag menstruum, but is always present as an active acid." He thinks on the contrary that alumina behaves as a base, especially with silicious slags, and has found that a slag high in alumina is often helped by the addition of silica. At the Copper Queen smeltery in 1901, when running copper sulphide ores containing gibbsite (hydrated alumina) he studied slags with as high as 32 per cent. Al_2O_3. It separates well in the forehearth and does not corrode the settler which lasts practically uninjured for the three weeks' run.

A slag was tried with SiO_2, 50.8 per cent.; FeO, 16.2; and CaO 25.4, but in this case the slag contained too much lime. The grade of the matte rose to 40 per cent., but the tonnage fell off, the tuyeres were hard to keep open, the hearth area became colder, the smelting focus rose in the furnace, and over-fire was caused. Upon going back to a slag having equal proportions of FeO and CaO the furnace again ran well.

Air is supplied by a No. 7 Connersville blower, furnishing 6300 cu.ft. per min., or 48,000 cu.ft. of air per ton of charge smelted.

High-silica slags are profitable in large furnaces, particularly if the ore is silicious and contains less than 3 per cent. copper.

Peroxidation of Iron in Copper-Matting Blast Furnaces.—Antenor Rizo-Patron gives his experience[1] in smelting certain raw sulphide copper ores containing gray copper, chalcopyrite and pyrite, and of the following composition: SiO_2, 27.6 per cent.; Fe, 25.7; Zn, 1.1; CaO, 0.7; Pb, 0.6; Cu, 6.1; S, 31.5; Sb, 6.3. Although the furnace was making a 20-per cent. copper matte and a sufficiency of coke and every combination of fluxes was repeatedly tried, yet it was impossible to obtain a fluid slag. Analyses of the slags obtained showed that they were of the proper composition to form fluid slags but that they had magnetic properties indicating that the iron was present as Fe_3O_4. An analysis of one such slag gave silica, 38 per cent.; iron oxide, 31.5; lime, 18. The same ores, partially roasted, were smelted in the same furnace, producing a 35-per cent. copper matte and a fluid slag of the following composition: SiO_2, 38 per cent.; FeO, 35; CaO, 18.3; and Cu, 0.34.

From the above experience it may be deduced that the iron of certain pyritic ores is easily converted into ferric oxides (Fe_3O_4 and Fe_2O_3), such conversions taking place low down in the stack where an oxidizing atmosphere prevails. On the contrary, when roasted ore containing ferric oxides is treated in the blast furnace, these oxides, reacting with the sulphates and sulphides, are easily reduced in the upper part of the furnace and remain in this condition as they descend.

In confirmation of the above, Charles F. Shelby at Cananea found that some ferric oxides were formed, and that these accumulated as a magma in the settler between the slag above and the matte below, forming a crust which eventually blocked it. The slag itself was, however, satisfactory. He thinks this condition may be favored by using too low a percentage of coke, or by running the furnace slowly so that the quantity of air entering is excessive.

Cananeo Ore-Bedding System.[2]—In the old system of handling, the

[1] *Eng. and Min. Journ.*, LXXXVIII, 367, 742.
[2] *Mines and Minerals*, XXX, 65; *Min. and Sci. Press*, XCVIII, 361; *The Mineral Industry*, XV, 249; XVI, 356.

ore was stored in 36 wooden bins having a united capacity of 5000 tons. It was shoveled from these into charge buggies, and with the fluxes and by-products, was wheeled to the furnaces, each furnace requiring 12 men per shift to supply it. The ore-bedding system which supplanted this practice is fully described in THE MINERAL INDUSTRY, XVI, 356, so that certain additional details only are given here.

Receiving Bins.—Some of the bins have steel hopper bottoms, and are discharged into chutes as desired, through gates actuated by racks and pinions. Beneath the chute of any bin to be discharged is a feed car so arranged that it may be moved along just above the 24-in. troughed conveyer belt that takes away the ore. This feed car is provided with a shaking feed-shoe, so that the flow of the chute is fed regularly to the conveyer belt and saves it from the impact of large lumps of ore. The feed-shoe is motor driven. This type of bin is now reserved for coarse ore and concentrates. In the other type of bin a shaking shoe is provided at the chute of each bin, also finger bars to control the too impetuous flow of the ore. The shoes are driven from a line shaft parallel to the conveyer belt, having an eccentric to each shoe. Each eccentric rod can be hooked to the rear of the shoe frame or disconnected as desired. A traveling chute can be brought to any desired bin serving to receive the flow of the shoe and deflect it to the belt with a drop of only an inch or two. Only 0.1 per cent. of the ore delivered by the troughed conveyers from the storage bins to the sampling mill is finally reserved for a sample. To do this a portion of the ore stream is taken out by one man at regular intervals as it falls from one troughed conveyer to another. The portion taken is cut down mechanically and the sample thus obtained is accurate enough for controlling the composition of the ore mixture.

Bedding Floor.—The bedding floor occupies a space of 150x450 ft., and is commanded by three longitudinal conveyers set 20 ft. above the floor. This allows an area of 50x450 ft. for each bed. Commonly such a bed 18 ft. high will hold 8000 tons, but as much as 10,000 tons can be crowded upon it. Bedding from the conveying belt occurs only on the backward movement of the traveling tripper which in this direction makes its run of 450 ft. in 80 sec. Its forward run takes 40 sec. The ore and fluxes are bedded together, the fluxes being calculated from the freshly made analysis of the bed. A uniform mixture for the furnace results. The coke is added separately at the furnace.

Reclaiming Machine.—The harrow which scrapes the inclined working face of the bed has a reciprocating movement of 18 in. imparted at the rate of 20 strokes per min. by a crank and connecting rod actuated by an independent motor. Another motor serves to slowly advance the machine against the face. It is claimed that because of the almost absolute uniformity of the mixture it is possible to make up a charge containing 75 to 80 per cent. of ore in place of 60 to 65 per cent. as when charging by hand.

While no specific costs are given it may be said that up to Jan. 1, 1909, the entire cost of operating the smelting division was reduced to 50 per cent. of the costs incurred prior to the suspension of operations on July 11, 1908. Since Jan. 1, 1909, a still farther reduction to about 40 per cent. of the former costs has been reported. Conveyer belts of the original installation are still in use, and other repairs have been trifling. The actual cost of bedding and charging is not yet available, but should not exceed 7c. per ton. Handling and bedding are done in 10-hour shifts. The reclaiming machines operate intermittently during eight-hour shifts, and working half time are able to supply the 2250 tons needed daily for the six furnaces.

After a year's trial of the system, Mr. Messiter offers the following in regard to it. With an expansion of the furnace plant from two up to eight furnaces no trouble was experienced in effecting a corresponding expansion in the bedding and conveying systems. The ore cars deliver their loads to a few bins of moderate capacity, yet large enough to take care of a train load at a time, and from there the ore on its way to the beds is broken and sampled in transit. Plenty of floor room is provided for bedding, which is executed in a thoroughly uniform way. The reclaiming machine, because of its simplicity, and because it removes the ore from the working face of a bed without any sudden falls of the ore, assures absolute uniformity of charge for as long a time as that particular bed lasts. From figures covering a large tonnage it is estimated that the cost of repairs on the reclaiming machines will be 0.2c. to 0.25c. per ton of ore handled. The first cost of three ore beds of 10,000 tons capacity each, including the reclaiming machines, is about one-half of the cost of steel bins, or three-fourths the cost of wooden bins of equal capacity.

Flue System and Stack at Great Falls, Mont.[1]—In addition to the description given in THE MINERAL INDUSTRY of last year, we add the following: The chimney is calculated to take care of 4,000,000 cu.ft. of gas per min., but is called on at present to dispose of but 1,500,000 cu.ft. at 600 deg. F.. It is designed to withstand the wind pressure of a gale blowing at the rate of 125 miles per hour. Its effective draft is designed to be 3.75 in. of water, which, with its internal diameter of 50 ft. would

[1] *Mines and Minerals*, XXX, 257; *The Mineral Industry*, XVII, 251; *Bull.* No. 37, A. I. M. E., 74.

be sufficient to develop 150,000 h.p. if used for a boiler plant burning 5 lb. of coal per hour per boiler horsepower.

Referring to the plan of the flue system, Fig. 7, page 250, of last year's volume, the dust chamber is seen to consist mainly of a rectangular portion 178 ft. wide by 367 ft. 4¼ in. long, divided by a central longitudinal wall. Beginning at the point marked P1 at the left, the chamber is filled with Rösing wires for a distance of 150 ft. Here the major portion of the dust, containing copper and silver, is deposited. Then comes a space of 50 ft. without wires where openings in the roof and bottom are provided for the admission of cold air. In the second area hung with wires the minor portion of the silver- and copper-bearing dust is precipitated, together with the arsenic which condenses on the wires, due to the lower temperature obtained by the admission of cold air at the empty 50-ft. space mentioned.

The second area with wires is 140 ft. long and is divided by a central longitudinal wall into two portions 86 ft. wide. In each half-flue 14 frames, each 85x10 ft., stretched with steel netting, are suspended by rods 10 ft. below the roof. Through this steel netting hang the Rösing wires. These steel frames receive a motion at right angles to the direction of the gas current. Outside the outer wall runs a line shaft in two lengths carrying eccentrics at 10-ft. centers set alternately to give opposite throws. Between the two sections of the shaft is set a 19-h.p. motor by which each section of seven eccentrics and their corresponding shaking frames can be operated either independently or together as may be desired. Each eccentric, through connecting rods and a bell-lever, operates its net-covered frame within the flue, giving it thirty 8-in. strokes per min. During the few minutes when the wires are to be shaken, the dampers toward the stack in that half of the flue are closed so that the dust may settle quietly into the hopper bottom below. Dampers of the butterfly type are provided both at the entrance and exit of the dust-chamber. There are 11 of them at the lower end and 10 at the upper or stack end, each 8 ft. wide. They can be used to regulate the draft but are employed primarily to close off either side of the dust-chamber during wire-shaking, cleaning out or when repairs are necessary.

Treatment of Heavy Spar Ores.[1]—At the Tyee smeltery, Ladysmith, B. C., a fluid slag and a clean separation of matte is obtained while treating baryta ore. The composition of this ore is given in THE MINERAL INDUSTRY, XV, 264, and a typical charge with the resultant products is presented in Mr. Maynard's article. The ore contains Cu, 4.4 per cent.;

[1] George W. Maynard, *Eng. and Min. Journ.*, LXXXVIII, 907.

Fe, 10.7; SiO_2, 12.7; $BaSO_4$, 42.1; Zn, 8; Ag, 2.85 oz.; and Au, 0.14 oz. per ton; and yields on smelting with 12.5 per cent. of coke, a slag with Cu, 0.36 per cent.; Fe, 19.3; SiO_2, 36.2; BaO, 23.7; ZnO, 7.4; Al_2O_3, 10; and a matte containing Cu_2S, 50.4 (Cu. 40.3) per cent.; ZnS, 16.1; FeS, 29.1; BaS, 3.6; indicating a concentration of 9 into one.

It would appear from a later note[1] that with a charge of two-thirds roasted and one-third raw ore and a minimum amount of fuel, the reduction of barite is practically completed at a temperature between 600 and 800 deg. C. The reactions are as follows:

$BaSO_4+2C=BaS+2CO_2$; and part of the BaS, then reacting with the FeO according to the reaction: $BaS+FeO=FeS+BaO$, enters the slag as a base, while the rest, as BaS, goes into the matte. That these reactions are true is evident from the fact that no SO_2 is to be found in the escaping gases. Baryta has, however, two disadvantages; first, its fluxing power is only 0.4 of that of lime (CaO); and second, being a heavy base, it lessens the difference of specific gravity between the slag and the matte, making a clean separation more difficult.

Substitution of Sulphides for Coke in Blast-Furnace Smelting.—According to Dr. E. D. Peters[2] a method followed at one large western plant has been to decrease the percentage of coke as the sulphur contents of the charge increased. In the case referred to a total of 18 per cent. for sulphur and coke was found to be sufficient. It made little difference in running the furnace whether there was 11 per cent. coke and 7 per cent. sulphur or whether the figures were reversed, giving 7 per cent. coke and 11 per cent. sulphur. The calorific effect of a pound of sulphur with its accompanying iron is not equal to that of a pound of coke, but the oxidized iron enters the slag and, the limestone in the charge being at the same time lessened, makes the slag more fusible.[3]

Smelting Plants.

The Washoe Smeltery.[4]—Certain improvements and additions to the plant were made in 1909. The amount of material handled in 24 hours is as follows: Ore, 10,000 tons; limerock, 2300 tons; coke, 550 tons; coal for reverberatory furnace use, 500 tons; coal for power, 50 tons; or a total of 13,400 tons. Eighteen hundred men are employed by the company at the plant.

Adjoining the concentrating mill there are eight storage bins for

---

[1] *Eng. and Min. Journ.*, LXXXVIII, 1180 *and* 601.

[2] Ibid., LXXXVIII, 735.

[3] It is to be questioned whether with so radical a change the furnace might not freeze up; though such an experiment might be carried on for a limited period before the furnace would begin to feel the results of the different charge.

[4] *Trans.*, A. I. M. E.. XXXVI; *The Mineral Industry*, XV, 255; *Eng. and Min. Journ.*, LXXXVIII, 243; Private notes.

second-class or concentrating ore each of 125 tons capacity, 13 storage bins for samples, each of 200 tons capacity; and one large coal bin of 2500 tons capacity is not now in use as the machinery of the concentrator and of the sampling mill is run by electric power furnished by the plant of the United Missouri River Power Company near Helena, Mont.

The sampling mill is in two sections each of 1800 tons capacity per 24 hours.

The fine slime from the concentrating mill is collected in a large settling tank, the underflow from which goes to the slime ponds, while the thin, watery overflow is used for condensing purposes, but principally for granulating and sluicing away the slag of the reverberatory and blast furnaces.

The roaster building, 96 ft. wide, has been increased to 412 ft. in length and now contains 64 McDougal roasters of the Evans-Klepetko type, each 16 ft. in diameter. The off-take flues from them are made of brick, replacing sheet steel.

CHARGE CALCULATION.

Material.	lb.	Silica.		FeO.		CaO.		Copper.	
		Per Cent.	lb.	Per Cent.	lb.	Per Cent.	lb.	Per Cent.	lb.
Concentrates	300	28	84	32	96			7	21
Ore	1800	52	935	14	252			7	126
Slag	1300	30	390	48	624			7	91
Lime	3800	7	266			47.4	1800		
Briquets (2000 dry)	2000	38	760	20	400			4.5	90
Ash of 1000 lb. coke			60		20				
Slag:									
40.6% SiO_2			2495		1392		1800		328
19.0% FeO			1163	(for matte)	229			(5% loss)	16
29.4% CaO			1800						
89.0%			5458		1163				312
Total weight of slag			6140					matte (45%)	693

There are eight reverberatories. The one last built (19x102 ft.) shut down in March, 1909, having run 365 days. It smelted 87,000 tons of calcines and 7000 tons of flue-dust, or 94,000 tons in all, including 3 per cent. of crushed limestone, and using 20.8 per cent. of fuel. This is equivalent to 260 tons of charge daily.[1] The fuel used is coal from Diamondville, Wyoming, which comes to the works in a coarsely crushed condition. It contains moisture, 4.5 per cent.; volatile matter, 38; fixed carbon, 46, and ash, 11.4.

At the briquet plant a large proportion of fine concentrates is used.

[1] *Bull.*, I. M. M., No. 63, 11.

Of the four briquetting machines, each of 700-ton capacity in 24 hours, two are used to make 1100 tons of briquets daily. The briquets contain 50 per cent. fine concentrates; 18 per cent. first-class ore; 27 per cent. pond slimes, and 5 per cent. of coke cinders from the reverberatories.

Of the three blast furnaces, two (51 ft. long) have a capacity of 1600 tons each daily, the 87-ft. furnace having a 3000-ton capacity. Together they have put through 6500 tons in 24 hours, but the average output is 1400 tons each for the two smaller furnaces and 2600 for the larger one, or 5400 tons in all. The 87-ft. furnace resembles the smaller ones, but has three settlers, three discharge spouts, and two water-cooled bridges. Experience shows that silica-brick paving on the bridge is unnecessary. A coating of sand would do as well, since the brick is shortly smelted away. The down-takes from the furnaces to the dust flues are 7 ft. in diameter and unlined. There are three of these for each 51-ft. furnace and five for the 87-ft. furnace.

C. Offerhaus gives detailed drawings of the 51-ft. blast-furnace, and enters into particulars of its operation.[1]

The table on the preceding page gives a charge calculation for the furnace.

If it is desired to make a 45-per cent. matte the 312 lb. of available copper will correspond to 693 lb. matte and it is assumed that said matte will also need 25.7 per cent. of its weight of Fe, or 33 per cent. of FeO. This, subtracted from the total of 1392 lb., will leave 1163 lb. to go into the slag. We then sum up the weights of SiO_2, FeO, and CaO, or 5458 lb., which constitutes 89 per cent. of the slag, and distribute the corresponding percentages, viz., SiO_2, 40.6 per cent.; FeO, 19.0; CaO, 29.4. A slag with about 40 per cent. SiO_2 is made, since, if the silica rises to 45 per cent., the furnace does not work well.

The comparative composition of two slags producing the same grade of matte is given in the accompanying table. Of the two, the second

COMPARISON OF SLAGS

	Cu. Per Cent.	SiO_2. Per Cent.	FeO. Per Cent.	CaO. Per Cent.	Cu in Matte.	Coke. Per Cent.	1st Class Ore Used. Per Cent.
Slag No. 1 (high lime)	0.23	42.2	17.9	29.5	45.0	11.7	21.6
Slag No. 2	0.33	40.2	22.5	26.9	45.0	10.7	16.2

slag, where the percentages of FeO and CaO are nearer one another, is preferred.

At present larger quantities of briquets, containing sulphur-bearing

[1] *Eng. and Min. Journ.*, LXXXVIII, 243.

concentrates are added to the charge, which may thus be increased to 12,000 to 14,000 lb., but no more coke is added.

An incident is given[1] illustrating what can be done with the large 87-ft. furnace in the way of repairs and changing of jackets while the furnace is in operation. Two doubtful metallurgists were shown a furnace being thus repaired. After some hesitation they accepted an invitation to enter the furnace, descended to the bottom of the shaft and stood upon the hearth, separated temporarily from the rest of the furnace by an irregular mass of partly chilled charge.

The converter building, 176 ft. wide, has been lengthened to 516 ft. There are 13 stands for converters, 96x150 in., and three 60-ton traveling cranes, two for handling converters, etc., and the other for moving slag and copper.

Of the three casting furnaces for copper, two of 110 tons and one of 140 tons capacity, two are constantly in use. The casting machine is of the endless-chain type, capable of casting 25 tons per hour.

In the power house there are now six Connersville and two Roots rotary blowers, each with a capacity of 30,000 cu.ft. per min., or 250,000 cu.ft. in all, equal to 360,000,000 cu.ft. in 24 hours under a pressure of 40 oz. per sq.in. For converter use there are seven horizontal blowing engines compressing 60,000,000 cu.ft. in 24 hr. at 16 lb. pressure. Three 90-lb. air compressors furnish air for shop tools, air gates, raising blast-furnace doors, dumping blast-furnace charge cars, tamping conveyers, etc. Four 900-lb. air compressors supply air for the locomotives of the local tramming system. Four hydraulic pressure pumps with accumulators pump water at a pressure of 360 lb. per sq.in. for the use of the hydraulic apparatus at the converter plant. The steam for the engines is supplied from the waste-heat boilers of the reverberatory system.

For the local tramming system there are now provided 17 air locomotives manufactured by H. K. Porter & Co., and weighing from 12 to 22½ tons each, also 240 cars of various kinds.

The Garfield Smeltery.[2]—The draft system has been simplified and made tight, and the converter fumes have been turned into independent stacks. An improved draft has resulted and the reverberatory charges are now readily melted. Forced or undergrate draft has been given up in favor of natural draft and grating now proceeds without interruption. The reverberatory furnaces make an output of 295 tons in 24 hours.

---

[1] *Eng. and Min. Journ.*, LXXXVIII, 735.
[2] *Min. and Sci. Press*, XCIX, 590; *The Mineral Industry*, XV, 280; XVI, 352; XVII, 240, 275; Private notes.

The conveying system has been modified so that it works smoothly; the old difficulties at the chutes having been overcome.

The method of feeding the blast furnaces has lately been changed. On each side of the furnace below the feed door is set a sloping bottomed hopper which delivers the ore at the level of the working floor (*f*, Fig. 5, The Mineral Industry, XVII, 243). Thus the ore slides instead of falling into the furnace. All ore for the blast furnace is the oversize of a $\frac{3}{8}$-in. screen. This not only lessens the amount of flue dust, but contributes toward faster running, so that a 4x20-ft. furnace puts through 550 to 600 tons of charge in 24 hours.

All coarse ore is now coarse-crushed at the delivery point, one-tenth of it being taken out by a large Vezin sampling machine and the rejected portion going at once to storage. The sample is sent to the sampling mill.

The converter slag, amounting to 500 to 600 tons daily, is molded in a Kelly slag-casting machine[1] and the slag sent to the blast furnaces.

The most important change is in the use of the basic-lined converter, patented by W. H. Peirce and E. A. C. Smith.[2] The converter was first tried out at Baltimore, then introduced at Garfield. The converter shell is approximately 10 ft. in diameter by 22 to 24 ft. long and is lined with magnesia brick 18 in. thick at the part which is lowest when the converter is in blowing position and 9 in. thick above. The shell is broken or interrupted above, the connection being made with tie rods so that expansion in the brick work may be taken care of by slacking off the tie rods. The cast-iron tuyeres set at 7-in. centers, are individual and are bolted to the shell within the wind-box. They are seated on asbestos gaskets so that they may yield as the lining expands. The throat for the escape of gases is in the cap as is usual, but near one end; the gases go off quietly with the projection of but few solid particles. Near the end but lower down on the shell is an independent spout for pouring, plugged with clay when not in use. As the converters are basic-lined, matte of any desired grade from 10 to 40 per cent. can be treated without difficulty. To the matte is added the calculated amount of silicious ore needed to produce the desired slag with the constantly forming iron oxide. The slag is tapped off from time to time and fresh matte and silica are added. A charge of 40 tons can be poured at a time. As much as 200 tons of copper has been produced with a single lining. One of these converters was installed in 1909 and the number has since been increased to three. The success of the basic-lined converter is now assured, but details of operation are naturally kept secret.

---

[1] *The Mineral Industry*, XVII, 275.
[2] U. S. Pat., 942, 346.

The blister copper is accumulated in a 50-ton tilting furnace heated by oil. This furnace resembles a barrel-type converter. When pouring a charge it is tilted so as to deliver a steady stream to the pouring ladle of a Walker casting machine which molds the copper into anodes.

The Huntington-Heberlein or pot-roasting plant has been given up. All the fine ore now goes to the reverberatory furnaces.

The Yampa Smeltery.[1]—This works is situated in Bingham Canyon, Utah, and is a notable example of a side-hill plant, having well-operated, moderate-sized reverberatory furnaces. At this works they have been successful in continuously converting 20-per cent. copper matte. We may estimate the capacity of the three reverberatory furnaces at 450 tons of charge daily, and the three blast furnaces at 1350 tons. The smeltery is now working two reverberatories and one blast furnace and taking care of 750 tons daily. Of this 600 tons come from the Yampa mine and 100 to 150 tons represent custom ores, these latter being as favorable for smelting and as self-fluxing as the Yampa ore itself. Yampa ore contains Cu, 2 per cent.; Fe, 27.7; SiO_2, 29.4; S, 28.8; CaO, 3.5, with $2.40 per ton in gold and silver.

The ore from the Yampa mine is delivered at the works by a Bleichert aërial tram line 12,300 ft. long, operated at a speed of 480 ft. per min., and delivering 750 to 900 bucket loads in 12 hours. The ore comes in buckets of 7 cu.ft. each and is dumped into the bins by hand. It is uniform in quality and is generally sampled at the mine. At the works a grab sample is often taken from the ore chute each half hour. For more careful work each tenth bucket is dumped into a sample bin. This is withdrawn to a 10x20-in. Blake crusher and is then elevated and put through a trommel 3 ft. 4 in. in diameter by 10 ft. long. The oversize goes to 14x28-in. rolls and is separately sampled as a furnace ingredient. The undersize is elevated, each twentieth bucket diverted for a sample, and a one-tenth portion of this taken out by a Vezin sampler. This sampling is done only on the night shift.

Before treatment the ore is separated into fines for the reverberatories, and into coarse ore for the blast furnaces. To do this it is fed to a trommel 3 ft. in diameter and 8 ft. long, having a plate screen with holes which vary according to the quantity of ore needed at the blast furnace; i.e., when more blast-furnace ore is needed, a ⅝-in., round-hole screen is used; if less is required, a hole as large as 1½ in. may be used. Then, since this undersize is too large for roasting, it is crushed to ⅝-in. size in the machinery above described.

The Roasters.—There are nine 18-ft., six-hearth McDougal roasters

[1] *Min. and Sci. Press*, XCIX, 255; Private notes, Dec., 1909; *Min. World*, XXX, 621.

for roasting the fine ore. In October, 1909, eight of these roasted 13,118 tons of raw ore per day, reducing the sulphur from 28 per cent. in the crude ore to 5 and 6 per cent. in the roasted product, with a loss in weight of 20 per cent., the crude ore as it comes in containing 3 per cent. moisture. This means that during that month 336 tons of calcines were produced daily by the McDougals, or 168 tons were smelted by each reverberatory furnace. A little limestone, 30 to 60 tons monthly, is added to the charge as seems advantageous. The roasters are driven by a 20-h.p. motor. The calcine is taken from the roasters in cars which hold 7300 lb. The Edwards roasters, formerly in use at this plant, have been thrown out.[1]

The Reverberatory Furnaces.—There are three reverberatory furnaces, 17x55 ft., 17x52½ ft., and 17x47½ ft., respectively. The furnaces are bound with 8-in. I-beams except at the doors, which are 15x24 in. These doors are provided for inspecting the charge. The fire box in each case is 6x12 ft., divided by a middle wall, and the ash pit is closed by tight doors. Either door may be opened for grating while the other half still carries the undergrate pressure. Blast for the furnaces is furnished by a No. 9 Buffalo fan driven by a 15-h.p. motor through a 16-in. pipe branching to each side of the ash pit. Air is also supplied to a cross flue, which takes in the row of checker-openings in the roof above the bridge. The secondary air is thus put in under pressure. Besides this another row of checkers or ports have been opened in the roof across the middle point of the hearth to supply enough air under natural draft to give a perfectly clear flame as the gases enter the neck of the furnace. The effect of using forced draft is that there is less suction within the furnace and hence, less tendency for air to be sucked in through crevices. In consequence, some carelessness is shown in luting the doors. Only the two charge openings near the bridge are used so that the total charge enters within 12 to 15 ft. of the bridge. The charge is dropped in two portions of 10 and 8 tons respectively. The average capacity of a furnace is 150 to 160 tons daily, the last-built or newest furnace doing the most satisfactory work. Ten tons of matte of an average grade of 30 per cent. Cu are produced daily. Slag is tapped once in three hours or less, and the aim is always to keep a good depth of matte in the furnace. This means a flow of about 15 tons of slag at a time. The slag is received in 60-cu.ft. or six-ton slag bowls mounted on trucks, and handled by a 13-ton electric locomotive. The reverberatory slag contains SiO_2, 37 per cent.; FeO, 50; CaO, 3.5; Al_2O_3, 6; and Cu, 0.35. Another analysis shows SiO_2, 39.3 per cent. and a silica content as high as this is often found.

[1] *The Mineral Industry*, XV, 253.

The matte is tapped into a series of cast-iron molds 20x48 in., holding 300 lb. In each mold is placed a loop having a cast-iron flat foot which holds it upright. The matte when tapped solidifies round this foot and when cool a chain block carried on a trolley is hooked into the loop. Thus, the cakes can be removed and sent to the blast furnace for smelting. The fact that the calcines are roasted to a lower sulphur content (5 or 6 per cent.) than is the practice elsewhere, means the formation of a larger proportion of ferric iron during the roasting. This reacts on the undecomposed sulphide, causing an elimination of more than half of the contained sulphur, and explains the high concentration of 15 into 1 obtained in the reverberatory furnace. The waste gases from each reverberatory furnace pass through a 300-h.p. Rust water-tube boiler, and generate steam at 110 lb. pressure. The necessary draft for each furnace is provided by a stack 7 ft. in diameter and 100 ft. high.

The Blast Furnaces.—The oversize from the trommels goes to sloping bottom storage bins whence it is drawn off as desired into side-dumping charge cars which will hold a ton each. A typical furnace charge would be 4000 lb. ore, 300 lb. matte, 1400 lb. limestone, and 600 lb. coke, the fuel being 10.2 per cent. of the charge. When the converters were running, "dope" charges consisting of 3000 lb. of sweepings and converter slag, limestone, and coke were used when necessary. The capacity of one furnace is 340 to 360 tons of ore or 450 to 500 tons of charge daily.

The steel blast-furnace building, 90x144 ft., contains three blast furnaces: No. 1 being 44x180 in.; No. 2, 42x168 in.; No. 3, 44x186 in. at the tuyeres. There is an 11-in. bosh on No. 1 and No. 3 and a 15-in. bosh on No. 2 furnace. No. 1 and No. 2 furnaces have two tiers of water jackets 7 ft. and 6 ft. high respectively, while No. 3 has a single tier 13 ft. high. The inner plate of the jacket is $\frac{5}{8}$ in. thick and the outer one $\frac{3}{8}$. No. 3 furnace only is now running. The actual hight at which the charge is carried is 3 ft. below the top of the jackets. The furnaces have broad, inclined distributing plates upon which the ore slides into the furnace. An end door is also provided by which to conveniently get at the interior of each furnace. The sill of the end door is 6 ft. lower than the feed floor and at the top of the jackets, so that it is but 3 ft. above the actual charge level. A floor placed 18 in. below this end-door sill is at a convenient hight for the men to stand on. The circular setlers or forehearths have shells 16 ft. in diameter and 5 ft. deep, and are lined at the sides with silica brick and a backing of 6 in. of sand. The bottom is lined to a depth of nearly 2 ft. with brick placed on end. Thus the interior dimensions are 13x3 ft. The matte is drawn off through a single tap hole near the back of the settler. The slag is run into 30-cu.ft.

slag pots and poured hot at the dump which has the remarkable hight of 70 ft. Each furnace is provided with a trapped spout of cast iron, water-cooled by a contained pipe coil, and has a water-cooled, cast-iron nose which can be readily replaced. The blast-furnace gases are discharged to a brick dust chamber 20 ft. wide, 20 ft. deep and 400 ft. long, having an inclined bottom sloping to side doors, 15x18 in., placed at 14 ft. centers. Through these doors the flue dust is drawn off into small cars. The dust chamber connects with a sheet-steel stack laid upon the steep hillside and terminating in a vertical portion 50 ft. high. The vertical distance from the furnace floor to the top of the stack is 254 ft. This stack, though unlined, is in good condition after five years' use. The blower equipment consists of two Connersville blowers of 100-cu.ft. displacement each and one of 55-cu.ft. displacement. One of the blowers is directly connected to a 100-h.p. engine run at 130 r.p.m.; the second is belt-connected to a 150-h.p. induction motor run at 140 r.p.m.; and the third is belted to a 70-h.p. engine run at 165 r.p.m. The blowers furnish blast at 30 oz. pressure per square inch.

An average analysis of the blast-furnace slag shows: SiO_2, 43 per cent.; FeO, 26.9; CaO, 22.1; Al_2O_3, 6.4; S, 0.7; and Cu, 0.19 to 0.21. The matte contains 20 per cent. Cu, but its grade is due to the addition of 20 tons daily of 30-per cent. copper matte from the reverberatories. An analysis shows Cu, 20 per cent., and Fe, 47.7 per cent. Alone it would go 14 per cent. copper.[1]

The Converters.—The converter building is 145x40 ft. and has a side wing or bay 116x22 ft. It contains two stands operated by a 30-h.p. direct-current, variable-speed, multipolar, inclosed type, series-wound motor, also six shells of the barrel type, 84x126 in., with 14 tuyeres. These are blown by one 250-h.p. 16 and 34x48 in., Allis-Chalmers blowing engine connected to duplex air cylinders, 34x48 in., with a capacity of 7800 cu.ft. of air per min. at 15-lb. pressure. A 20-ton traveling crane handles ladles and converters.

With this equipment, working two shifts out of three in 24 hours, 20-per cent. copper matte was successfully treated. The two stands were worked together, each starting with a five-ton ladle of matte tapped in from the settler. This matte was raised to white metal, the slag poured, and another ladle or matte added to each vessel. This was again brought to the grade of white metal, the slag removed, then the contents of one converter was poured into the other where it was blown to a 99-per cent. blister copper. An instance of the similar treatment of a low-grade

[1] This 20-per cent. matte yielded by the blast furnace is now shipped to the Garfield smeltery as it was found to be cheaper to treat it there than at the Yampa works.

matte of less than 30-per cent. Cu will be found in the former practice at the United Verde plant, Jerome, Ariz.

Steptoe Valley Smeltery.[1]—This plant at McGill, Nev., was erected principally for the treatment of ores from the mines of the Cumberland-Ely and Nevada Consolidated companies, but also for custom ore. It is situated on a side hill and the ore is handled by gravity. Information regarding the smeltery is given in THE MINERAL INDUSTRY, XVI, 342 and XVII, 206. Further particulars covering practice in 1909 are as follows: The work is approached on its upper level by a wood and steel trestle, 1000 ft. long, and at its highest point 125 ft. above the ground. Beneath this trestle is the sampling mill the operation of which has been made automatic as far as possible, and which contains a No. 7½ gyratory crusher, a Blake crusher, a set of rolls, three Vezin sampling machines, a trommel, elevator and two belt conveyers.

The plant is handling daily 800 tons of sulphide concentrates, which carry 18 to 20 per cent. copper and 30 per cent. silica. It includes three principal buildings for the roasters, the reverberatories and the converters, each having its own stack.

The roaster building contains 16 six-hearth McDougal furnaces, 18 ft. in diameter, with the central shaft and the rabble arms cooled by air instead of by water as heretofore, the result being an increased tonnage. There are two automatic feeders to each furnace, one for the concentrates, and one to supply 6 to 8 per cent. of limestone to mix with the ore.

In the reverberatory building there are three reverberatories in operation, a fourth nearly completed, and a fifth being excavated for. Two of the furnaces have Stirling boilers, and one has Babcock & Wilcox boilers. The Stirling boilers are preferred, and the new furnaces will be furnished with them. The matte containing 50 per cent. Cu is tapped into ladle cars, weighed and hauled by a locomotive to the converter building. The slag is granulated by tailings water from the concentrating mill.

The converters are operated electrically using an alternating current. Each converter has a capacity of 25 to 30 tons of blister copper per day. The blister copper is poured from the converter into 10-ton ladles, and is taken by a traveling crane to one of two endless-chain casting machines. This crane has a main motor capable of lifting 60 tons, and two auxiliary motors which can lift 25 tons each. The installation of an alternating current for this work has proved to be successful. The 10-ton ladle, into which the blister copper is drawn, is placed in a

[1] *Mines and Methods*, I, 72; *Min. World*, XXX, 273.

cradle, tilted and poured by a hydraulic apparatus (see THE MINERAL INDUSTRY, XVII, 274) into the molds of the casting machines. The slag from the converters is poured into the reverberatory furnace from slag pots which have transferred it from the converter house.

Blast for the converters is furnished at a maximum pressure of 17 lb. per sq.in. by three compound blowing engines. Two of these are Allis-Chalmers engines with capacities of 6000 and 13,000 cu.ft. of air per min. The third is a Nordberg cross-compound engine with a capacity of 18,000 cu.ft. of air per min.

The Balaklala Consolidated Copper Company's Smeltery.[1]—This plant is at Coram, Shasta county, Cal. The equipment of 1250 tons daily capacity is for both blast-furnace and reverberatory smelting, the resultant matte of both operations being converted. It comprises four 18-ft. McDougal roasting furnaces; three 56x240-in. blast furnaces; one reverberatory furnace with a hearth area of 17x92 ft., having two Stirling waste-heat boilers; two electrically operated converter stands, having six converter shells 96 in. in diameter by 150 in. long; and three casting machines for casting matte. The latter are not needed at present, since the matte is converted and not shipped as was at first intended. There are two sampling mills, one with a capacity of 25 tons per hour for custom silicious ores and one with a capacity of 10 tons per hour for copper sulphide ores. Storage bins of the following capacities are provided: sulphide-ore bins, 7000 tons; silicious-ore bins, 6500 tons; limestone bins, 3600 tons; coke bins 4500 tons; and bins for matte, 800 tons.

The power plant contains three 256-h.p., oil-fired, Stirling boilers which with the waste-heat boilers, furnish steam to three 14x13x36-in., 450-h.p., tandem-compound, condensing engines. These are direct-connected to three 300-ft. rotary pressure blowers. There are also one cross-compound blowing engine and one 150-k.w. generator operated by a direct-connected, 225-h.p. motor.

The ore is pyritic, containing Cu, 2.7 per cent.; SiO_2, 25.8; Fe, 30.3; Al_2O_3, 4.1; S, 37.5. The coke, limerock and silicious ores are received at the plant on railroad cars; the sulphide ores come from the company's mines by aërial tramway. At the discharge terminal of the tramway the sulphide ore is sized on a $\frac{1}{2}$-in. mesh screen the undersize going to the fine-ore bins and the oversize to the coarse-ore bins. The fine ore is roasted until its sulphur content does not exceed 6.5 per cent., and is then smelted in the reverberatories, together with the blast-furnace flue

[1] *Eng. and Min. Journ.*, LXXXVII, 502; *The Mineral Industry*, XVII, 268; The first official report of the company for the year 1908; Private notes.

dust. Blast-furnace work is in two stages. The coarse sulphide ore (over ½-in. size) is smelted with silicious ore and limestone, producing a clean slag and a low-grade matte containing 8½ per cent. copper.

The furnaces have tuyeres bushed down to 2½-in. apertures and are driven at a blast pressure of 48 oz. The ore furnaces put through daily a charge consisting of 500 tons ore and 120 tons limestone or 620 tons of charge, using 6.5-per cent. coke. For the concentrating furnace the daily charge is composed of ore, 290 tons; limestone, 82; converter slag, 34; silicious ore, 60; matte of the first fusion, 125; or a total of 591 tons daily, using 7.6-per cent. coke, and yielding a high-grade matte. The oil-fired reverberatory furnace treats daily 145 tons of charge composed of flue dust from the blast furnaces and calcines from the McDougal roasters. Four oil burners are used in firing the reverberatory, but heating with three, set closer together, will be tried, since with four a rapid cutting away of the side walks takes place. The furnace produces a matte containing 26 per cent. Cu, and a slag with Cu, 0.45 per cent.; SiO_2, 37.4; FeO, 47.1; Al_2O_3, 16; and CaO, 2.4.

The ore is taken from the storage bins to the furnaces in scale charge cars, and the slag to the dump in slag cars drawn by electric locomotives. The converter building has an electrically operated traveling crane.

Operating costs per ton of ore treated during the latter part of 1908, based on one furnace smelting 453.6 tons of charge daily were: Blast-furnace smelting, $2.035; matte and slag casting, $0.177; converting, $0.07; repairs to buildings of plant, $0.057; repairs to ore bins, $0.084; railroad operation and maintenance, $0.108; unloading custom ore, $0.047; sampling of custom ore, $0.035; sampling of sulphide ore, $0.089; electric lighting, $0.045; water supply and pumping plant, $0.016; assay office, $0.032; general expenses, including insurance and taxes, $0.128; total smelting expense, $2.924. The cost of sampling custom ores was 52c. and for sulphide ores nearly 10c. per ton. Allowing for no loss in converting and retreating by-products, the recovery appears to be 99.5 per cent. of the gold, 94.5 of the silver and 92.6 of the copper. There was 5.9 per cent. of coke used per ton of charge, this including ore, matte and slag retreated, and limestone. Thus far operations have not been of sufficient extent to confirm estimates of $2.50 per ton of ore reduced to matte, and about $15 per ton of copper converted from matte.

The average content of all ores treated was Cu, 2.45 per cent.; Au, 0.028 oz.; Ag, 0.78 oz. per ton. The Balaklala sulphide ore contained Cu, 2.53 per cent.; Au, 0.016 oz.; Ag, 0.71 oz. per ton; the Trinity sulphides Cu, 2.78 per cent.; Au, 0.032 oz.; Ag, 1.02 oz per ton.

The Granby Smeltery.[1]—The reduction works of the Granby Consolidated Mining, Smelting and Power Company, Grand Forks, B.C., has been increased to a capacity of 4000 tons daily, the eight furnaces having been lengthened to 23 ft. from their original length of 17½ ft. The furnaces are set transverse to the axis of the furnace building, and hence cannot be lengthened by throwing two or more furnaces into one as has been done at the Washoe plant.

The bin structure is in one block, 764x75 ft., and is divided into five rows of storage bins. Three rows of bins are used for ore and two for fuel. Each row of ore bins is divided into 50 compartments, each 13 ft. long, and has 450 hopper bottoms sloping toward side chutes. The coke bins are not divided into compartments and have flat bottoms. The bins have the following capacities: Row No. 1, 3000 tons of ore; No. 2, 3300 tons of coke; No. 3, 5000 tons of ore; No. 4, 3300 tons of coke; and No. 5 (nearest the furnaces) 5000 tons of ore. This gives a total capacity of 13,000 tons of ore and of 6600 tons of coke. When full the ore bins will carry a supply of ore sufficient for a little over three days. Over each row of bins extends a railroad track, these tracks uniting at the weighing house where loads and empties are weighed by automatic railroad scales. The ore comes to the works in four trains with a total of 105 to 110 hopper-bottomed cars of 30, 40 and 50 tons' capacity. As the ore is lumpy, it is discharged with but little trouble in warm weather, and by prompt delivery of the cars during cold weather freezing of the ore causes less trouble than would be anticipated. The ore is hauled to the works from the mine at Phoenix, 24 miles distant, over branch lines of the Canadian Pacific and Great Northern railways. As the grade to the mine is about 3 per cent., there is difficulty in returning the empties. The coke comes in box cars, each furnished with four trap doors of 2x6 ft. With these convenient openings one man can empty two cars per eight-hour shift.

The ore is rather soft, often comes in large pieces, and is of the following average composition: SiO_2, 38 per cent.; Fe, 12; CaO, 18; MgO, 7; Al_2O_3, 7; S, 3.5; Cu, 1.2 to 1.7; As, 0.008; Sb, 0.015; Ag, 0.4 oz.; and Au, 0.075 oz. per ton. The ore mined in one year will not vary 2 per cent. in SiO_2, 1 per cent. in CaO, or 1 per cent. in S from these figures. When the ore is of uniform quality, sampling at the works is not constantly done. When it is done one car in ten is reserved and delivered to a special sampling bin. The ore is withdrawn from this bin and sent to the sampling mill. In the sampling mill, storage bins are provided for samples, and by means of a revolving head, a sample can be shot to

[1] *Min. and Sci. Press*, XCVIII, 256; *Journ.* Can. Min. Inst., XI.; Private notes, Aug., 1909; *The Mineral Industry*, XIV, 143; XV, 223; XVI, 352; XVII, 268. "The Copper Handbook," VIII, 732.

any desired bin. The metal content of the ore being so uniform, careful sampling is not needed; in fact, the value of one lot of 30,000 tons will not vary more than 20c. per ton from that of another similar quantity.

With a matte-fall of 3 to 4 per cent., the blast furnaces yield a matte containing 35 per cent. Cu, and a silicious slag. This matte-fall indicates a volatilization of 65 per cent. of the sulphur, or a loss of 2.25 per cent. of the 3.25 per cent. originally present in the ore. This amount is so small as not to affect vegetation, except on the slopes of the hills immediately adjoining the works.

The matte and slag are separated in two forehearths placed in series, the second and smaller one acting as a guard for the first, and effecting another settling. The tapping is from the front end of the furnace, so that there is a long flow of 23 ft. from the back. The guard settler has a slag spout on either side, and the slag track branches so that a slag pot may be placed under either spout. Two pots are brought to one side and one to the other. When one of the two pots is filled the second is moved under the spout and likewise filled. When both pots are filled they are hauled out, the slag stream in the meantime being stopped and the spout on the other side opened. The slag is hauled away by one 14-ton, 3-ft.-gage locomotive in trains of three slag cars, each car of 44 cu.ft. or 4 tons' capacity. One locomotive and six slag cars will handle 800 to 850 tons of slag in 24 hr., provided the dump is not more than 1500 ft. long. One locomotive and 10 slag cars are held as a reserve. The slag pots dump automatically. They are bottom-heavy when empty and top-heavy when full. The bowls of the pots are cast in halves and bolted together to prevent cracking, due to continual expansion and contraction. These pots have given good service but are too small when a furnace has a capacity of more than 400 tons per day.

The matte, amounting to 140 tons daily, is tapped out of the forehearths, principally from the first and larger one, into cast-steel matte ladles which hold three tons. The ladles are carried by a small traveling crane to the converter house which is 68x240 ft. Here it is received by a 40-ton crane and the still molten matte dumped into the converter. The lining department of the converter house has one crusher and two mixing pans for the preparation of lining material. The converters are tamped by machines.

In operating the converter upon 35 per cent. matte, the slag must be poured off three or four times. It is received in a slag ladle which is set on an automatic pouring device. This gradually empties the slag into the molds of a slowly-moving inclined chain elevator, and the molded slag, passing under cooling streams of water is solidified sufficiently to be dumped into a bin at the head of the elevator. This slag contains considerable copper and is returned to the blast furnaces. When conversion is complete the blister copper is poured into an adjustable spoon or small ladle, which directs the stream smoothly into a set of molds mounted on a truck and running transversely beneath the converter. There are three trucks for each converter. The blister copper, carrying 98 to 99 per cent. Cu, 40 oz. Ag, and 7 oz. Au per ton is shipped to the Nichols Copper Company, Laurel Hill, N. Y., for electrolytic refining.

The large masses of slag and copper from the shells and ladles, which accumulate in the converter house, are picked up by the crane and deposited near one end of the building. Here they are broken up by a drop-weight of 2000 to 3000 lb. falling from a hight of 30 to 40 ft., an effectual way of doing the work, borrowed from foundry practice.

In the blower department, besides smaller machines, there are two Connersville blowers of 300 cu.ft. displacement, each run by two 150-h.p., directly belted induction motors. In starting up against full pressure of air in the main, a relief valve is first opened and the motors set revolving. The valve to the blast main is gradually opened and the escape valve is shut off. Current is then increased until the blower is at full speed. There is no indication of slipping of the belts, showing that each motor is doing its full duty. There are two parallel, cross-connected blast mains, one proceeding from each blower room at either end of the blast-furnace building. This insures a constant and steady supply of air which travels a minimum distance to the respective furnaces. The blower department also contains a double-cylinder Allis-Chalmers blowing engine of 10,000 cu.ft. per min. capacity at a pressure of 12 to 14 lb. per sq.in. This is driven by a 500-h.p. direct-connected electric motor.

The Trail Smeltery.[1]—The company has lately reorganized under the title of the Consolidated Mining and Smelting Company of Canada. The plant is situated on a hillside and has departments for silver-lead and for copper smelting, treating both ore from the company's mines and custom ores.

In the copper department the ores are matted in blast furnaces to a low-grade product which is re-treated and the resultant higher grade matte shipped to Tacoma for converting.

The ores most largely used are from Rossland, an adjoining mining camp. Average analyses of ores from this place are given in the table on following page.

These ores are notably high in alumina and are becoming more silicious

[1] *Bull.* Can. Min. Inst., July, 1909; *The Mineral Industry*, XI, 196; *Aust. Min. and Eng. Rev.*, July 5, 1909, 315; Private notes.

every year. Their chief value lies in their gold content. Other principal ores are: Snowstorm ore from Mullan, Idaho, containing Fe, 4 per cent.; SiO_2, 85; Al_2O_3, 3.5; S, 3; CaO, 3; Cu, 4; and Ag, 6 oz. per ton; Snowshoe ore from Phœnix, 100 miles distant in the Boundary district, containing Fe, 10 per cent.; SiO_2, 35; CaO, 22; S, 3; Al_2O_3, 4. Limestone is obtained from the foot of Lake Christina, 79 miles away.

The copper ores are delivered from railroad cars by overhead tracks into sloping-bottom storage bins, from which the ore is withdrawn for coarse crushing and automatic sampling.

The wooden blast-furnace building has been replaced by one of steel construction. There are five copper-matting furnaces; two, 42x240 in., at the tuyere level; two, 42x300 in., and one, 42x263 in. Each furnace has 36 tuyeres. The first two have a capacity of 425 tons each; the second two, 520 tons, and the fifth, used for concentrating the low-grade or first matte of the other four furnaces, has a capacity of 425 tons daily. With four out of the five in operation we may estimate the capacity of the plant at 1800 tons of charge daily. The furnaces are set transversly to the length of the building, and the charge tracks run on both sides of the furnaces.

ANALYSES OF ROSSLAND ORES.

Ore.	Au. Oz. Per Ton.	Ag. Oz. Per Ton.	Cu. Per Cent.	Fe. Per Cent.	SiO_2. Per Cent.	CaO. Per Cent.	S. Per Cent.	Al_2O_3. Per Cent.
I	0.44	0.5	1.1	19.8	43.0	8.7	7.2	15.0
II	0.50	0.3	0.9	22.0	37.0	4.2	10.8	14.9
III	0.10	0.5	0.7	15.5	42.1	17.6	6.8	....
IV	1.18	2.3	3.6	....	....	....	....	....

The ore is withdrawn from the storage bins into trains of five charge cars each. These trains are handled by 10-ton Jeffrey electric locomotives. The cars hold 1000 lb. each, and have scoop-tray bodies pivoted to swing sideways for dumping. When they arrive at the furnace they are dumped, one at a time, while in motion so that there is a spreading of the ore from end to end of the furnace. A typical train load would consist of three cars of ore (4000 lb.), one of limestone (750 lb.), and one of coke (350 lb.). Rossland ore, however, needs 25 per cent. of its weight of limestone for fluxing. Within one of the furnaces, parallel to the sides, are hung steel deflecting plates so arranged that as the ore slides into the furnace the larger pieces of the charge, which would naturally roll to the other side of the furnace, are diverted and retained on their own side. The impact of the falling charge tends to swing the plates aside so that there is room for the charge to find its way downward. The arrangement appears to be satisfactory.

One is impressed by the fact that there is but little overfire, and that in consequence the heat is where it is most needed, viz., at the tuyeres.

The ore furnaces are run to give a slag to contain SiO_2, 42 to 44 per cent.; FeO, 24; CaO, 17; Al_2O_3, 14 to 17; Cu, 0.15 to 0.2; and Au, 0.01 to 0.04 oz. per ton. The matte contains 6 to 15 per cent. Cu. Each blast furnace is run with a matte-fall of 10 to 14 per cent. with a trapped spout, and the flow passes through two settlers in tandem. The slag is granulated. The matte is tapped from the settlers on either side, the tap hole on one side being 10 in. higher than on the other. It is received in pots, taken to a grating at the floor level, and poured through the grating into a launder where it is granulated by a strong jet of water. This sweeps it away to the foot of a belt elevator which raises it to storage bins. This granulated low-grade matte is then ready for roasting.

For roasting there are provided two straight-line furnaces of the O'Hara type, having hearths 12x110 ft., where the matte is roasted until its sulphur content does not exceed 12 per cent. This is then sent to the Huntington-Heberlein pot-roasting converters, of which there are nine, 8 ft. 8 in. in diameter, capable of holding 10 tons each. It is mixed with fine ore and flue-dust, wet down, and blown to yield a product containing as low as 1 to 3 per cent. sulphur. A pot has a false bottom or diaphragm of cast iron, made in four radial sections bolted together, this construction being more serviceable and durable than when cast in one piece. Cast-steel diaphragms have been tried, but have failed because the heat distorts them. The pots or converters are operated as follows: A few slabs of wood are thrown in, also a shovelful of glowing coals from the roaster firebox, and a light blast turned on until this wood is burning briskly. The charge is now run into the pot while the blast is increased to 6 or 8 oz. per sq.in., then gradually decreased until, when the fire has arrived at the surface and the charge is nearly burned out, but 2 oz. per sq.in. is used. This takes eight hours. The converter is then inverted on its trunnions, and the charge falls out, mostly in a lump, upon a cast-iron cone which breaks it into large pieces. These pieces are broken by hammer until they can be put into a 20x20-in. Blake crusher.[1] The material is crushed to pass through a 6-in. ring, and is then sent by elevator to the furnace storage bins. It will be noticed that, since there is no reverberatory treatment, it is necessary to agglomerate the product before sending it to the blast furnace. The charge for the concentrating blast furnace consists of 700 lb. of this roasted product, 2000 lb. of Snowshoe ore, 300 lb. Snowstorm ore, and 350 lb. coke, and yields a matte containing 42 per cent. Cu, 50 oz. Au, and 40 oz. Ag per

[1] This is too small and adds to the labor-cost. Elsewhere a 24 x 36-in. crusher has been used.

ton. This is broken up, sampled and sent by rail to Tacoma for converting. The slag from this furnace contains SiO_2, 38 per cent.; FeO, 50.7; CaO, 4.7; Cu, 0.4; Au, 0.02 oz.; and Ag, 0.1 oz. per ton.

Even though the cost and loss in granulating and roasting the matte be considered, the smelting practice above outlined has been found better than that of producing a 20-per cent. matte in the ore furnaces, followed by concentration of that matte with silicious ore low in sulphur. Rossland ores are low in copper and sulphur, and high in the slag-forming elements, silica and alumina, as well as in gold. To produce a 20-per cent. copper matte there would have to be a silicious slag and a high concentration, both of which would tend to cause a loss of gold.

The settlers eventually fill with infusible or chilled material and have to be replaced with fresh ones. Bottoms, of the full size of the settlers, are removed to the edge of the dump and there broken up by means of a two-ton drop weight falling 70 ft. This method is more satisfactory than to use dynamite. The dump is high and adjoins the Columbia river.

Works of the British Columbia Copper Company, Ltd.[1]—The smeltery is situated at Greenwood, B. C., and receives ore from its principal supplying mines, five miles distant, via the Canadian Pacific Railway. The buildings are of steel construction.

The run-of-mine ore, some of it in large lumps, is coarsely crushed in a separate building by a large gyratory crusher, then sent by troughed belt conveyer to storage bins capable of holding 10,000 tons. Storage bins are also provided for 2000 tons of coke. These bins are supplied from an overhead railroad track, and the ore and fuel is delivered to them by hopper-bottom cars of 30 to 50 tons each.

There is a three-story automatic sampling mill, 65x79 ft., the ore from which is sent by belt conveyer to those storage bins intended for custom ore.

The blast-furnace building has three 700-ton blast furnaces, 48x240 in. at the tuyeres, set transversly to the length of the building on the tapping floor, a central bench 8 ft. above the main ground floor of the building. Down-takes from the furnaces lead to a dust flue, 620x12x14 ft., and thence to a stack, 121 ft. high. Upon the tapping floor are the settlers, which are 16 ft. in diameter. There are five 15-ton Baldwin-Westinghouse electric locomotives, three for charging the furnaces, etc., and two for removing the slag by an up-grade track to the edge of the dump. The slag is received in 25-ton, side-dumping ladle-cars, top-heavy when full and bottom-heavy when empty, each having an electric motor with a worm-gear for dumping the pot, all operated from the locomotive.

[1] "The Copper Handbook," VIII, 413; *The Mineral Industry*, XI, 197; Private notes.

In the power house are three Connersville blowers, each belted to a 300-h.p. induction motor.

The aim is to produce a blast-furnace slag containing SiO_2, 42 per cent.; FeO, 21.9; and CaO, 25; and a matte varying from 15 to 55 per cent. Cu, according to the grade of ore smelted. The bulk of the ore treated has a quartz-calcite gangue containing magnetite. The copper occurs as chalcopyrite and the ore carries Cu, 1.5 per cent.; Ag, 0.2 to 0.5 oz., and Au, 0.05 to 0.10 oz. per ton. If the ore carries more base than the slag demands, silicious custom ore is added to the charge. If, on the other hand, the ore proves to be too silicious (a condition which rarely occurs), then the more basic Oro Denora ore is put in, this being a pyrite chalcopyrite ore with a quartz-silica gangue. All the ores now treated are a little deficient in sulphur, and on this account, a pyrrhotite ore from the Napoleon mines near Marcus, Stevens county, Washington, is employed. The ore is low grade, carrying a little copper, silver and gold, with about 20 per cent. SiO_2, and 40 per cent. Fe. As little of this ore is used as possible, as the metal content is not sufficient to pay for the freight and for the cost of treating it. Twelve per cent. of coke, costing $6.50 per ton, is used in the furnace charge.

The converter building, immediately adjoining the blast-furnace building, contains two stands with 84x126-in. shells. The molten matte is taken directly from the settlers to the converters and produces an unusually pure blister copper containing 99.3 per cent. Cu, 20 to 50 oz. Ag, and 10 to 25 oz. Au per ton. This is sent to the Chrome plant of the United States Metals Refining Company for electrolytic refining. The shells and ladles are handled by a 40-ton, 4-motor, traveling crane.

The Cerro de Pasco Smeltery.[1]—This plant, properly known as La Fundicion de Tinyahuarco, is situated 213 miles by rail from the port of Callao, Peru. The coal mines at the company are at Goyllarisquisga 30 miles distant, and furnish monthly about 20,000 tons of coal high in ash. The ore, principally from the Cerro de Pasco mines, is soft and breaks readily to fines and is produced at the rate of 18,000 tons per month. Part of the ore comes from Morochoca, 116 miles by rail. The ores are sulphides containing pyrite, chalcopyrite, galena, blende and tetrahedrite with a little malachite, azurite and chrysocolla, all in a silicious gangue. The Cerro de Pasco ores vary from 4 to 15 per cent. Cu, 4 to 13 per cent. Pb, and from 3 to 10 oz. Ag per ton; the Morochoca ore varies from 9 to 13 per cent. Cu, has no lead, and carries 10 to 15 oz. Ag per ton. About 1400 tons of ore, limestone and coal are delivered at the works daily. The ore is screened at the mine over a $3\frac{3}{8}$-in. grizzley

---

[1] *Min. and Sci. Press* XCVII 637. *The Mineral Industry*, XVII, 262; Min. Mag., I., 185.

to separate the fines. Bins for limestone and ore are of the same type, having flat bottoms and steel frames with wooden linings. Their united capacity is 15,000 tons. Ore to be sampled is deposited in steel hopper bins at the sampling mill. This mill contains two Blake crushers 24x18 in. and 20x13 in., respectively, two sets of rolls, 40x15 in. and 8x4 in., respectively, three Vezin samplers and one Bridgman sampler.

The coal, aside from that going to the power house, is delivered to bins at a coal washery. Here two commercial products are made, a steam or nut coal ($\frac{3}{4}$ = to $1\frac{1}{2}$-in. size) used for the reverberatory furnaces and for the locomotives, and a coking coal and sludge (all finer than $3\frac{3}{4}$-in. size) for coke making. The washery has a capacity of 350 tons of run-of-mine coal in nine hours, running the day shift only and yielding 250 tons of useful coal and 100 tons of waste. The coking product, containing 5 to 12 per cent. moisture, is delivered to a nine-ton double, side-dump larry and is hoisted by incline to the ovens. These are bee-hive ovens $12\frac{1}{2}$ ft. in diameter by 8 ft. high and produce 3.45 tons of coke from 5.8 tons of coal each 48 hours. From 100 to 120 tons of coke are produced daily. The coke is granular, strong and fairly porous, and can be got in large lumps. The following analyses are representative:

ANALYSES OF FUELS USED AT THE CERRO DE PASCO SMELTERY.

Material.	Volatile Matter. Per Cent.	Fixed Carbon. Per Cent.	Ash. Per Cent.	Sulphur. Per Cent.
Run-of-mine coal	37.1	32.2	30.8	1.62
Steam or nut-coal	41.8	35.6	22.6	0.98
Coking product	40.8	38.2	21.2	1.33
Refuse from washery	24.0	14.8	61.2	3.75
Coke from coking product	1.6	66.3	33.5	0.90

The ash from the coke contains SiO_2, 60 per cent.; Al_2O_3, 28; FeO, 9; MgO and CaO, 3 per cent.

There are four blast furnaces, three 56x180 in., and one 50x180 in., all set longitudinally in the building. The furnaces have a 12-in. side bosh, but no end bosh, and have 12 jackets each, four on each side and one at each end. There are 14 tuyeres per side 4 in. in diameter, set at 12-in. centers. The furnaces have closed tops, two with goose-neck downtakes to a brick dust flue, 10x12 ft. in cross-section, and thence through a dust chamber 20x28 ft. cross-section, and 200 ft. long to a steel stack 220 ft. high, with an inside diameter of 22 feet.

There are five settlers, 16 ft. in outside diameter and 5 ft. deep, placed at the ends of the furnaces. At present only two are used, each taking the flow from two furnaces. In case of need, the spare settlers stand ready for use. Matte is tapped from the settlers at right angles to the entering flow. The slag is drawn off on the opposite side from the matte into a launder consisting of a 12-in. channel-beam fitted with sheet-iron sides where it is granulated by water. Close to the dump is a dewatering arrangement by which about 60 per cent. of the water is recovered, flows to a cooling tower, and is then returned by centrifugal pumps for re-use at the blast furnace.

A charge train consists of six $2\frac{3}{4}$-ton side-dump cars drawn by a Davenport steam locomotive. In charging, 9 to 11 per cent. of coke is first put in from two 500-lb., two-wheeled buggies, then, alternately at either side of the furnace every 20 to 30 min., two cars of five tons of charge. The charge consists of 18 to 20 per cent. limestone, 20 per cent. converter slag, and 60 to 65 per cent. of ore. The temperature of the escaping gases at the stack varies from 180 to 350 deg. C. Sulphur dioxide gas is often plentiful on the charge floor, depending on the direction of the wind. About 75 per cent. of the contained sulphur in the charge is volatilized. For further particulars of operation see the article on "Blast-Furnace Practice at Cerro de Pasco," elsewhere given in this paper. The following table gives the average composition of the materials of the charge and of the products of the blast furnaces.

ANALYSES OF ORE, LIMESTONE AND BLAST-FURNACE PRODUCTS AT CERRO DE PASCO.

Material.	SiO_2. Per Cent.	Fe. Per Cent.	CaO. Per Cent.	Zn. Per Cent.	Pb. Per Cent.	Al_2O_3. Per Cent.	S. Per Cent.	Cu. Per Cent.	MgO. Per Cent.	Ag. Per Cent.
Ore	21.5	24.1	....	4.2	4.1	4.7	30.9	7.8	....	9
Limestone	2.7	tr.	49.1	....	....	1.1	....	....	3.4	....
Flue dust	18.0	21.0	3.0	4.0	9.0	7.0	11.0	8.0	....	12
Slag	39.0	28.4	10.5	4.0	0.4	6.0	0.2	0.24	....	0.16
Matte	0.7	22.8	....	4.9	6.6	....	22.6	37.8	....	38.5

The furnaces put through 600 to 640 tons daily with a concentration of five into one. Blast is provided by three No. 11 Roots blowers with a displacement of 350 cu.ft. each, running at 120 r.p.m. They supply 126,000 cu.ft. of air per min. at 24-oz. pressure per sq.in. Each blower is driven by a Nordberg tandem-compound Corliss engine, 15x30x36 inches.

There are two electrically driven, six-hearth roasting furnaces of the McDougal type, 18 ft. in diameter, and taking 3 h.p. each. They each handle 65 tons of ore fines and flue dust daily or 130 tons in all, and roast fines $\frac{1}{2}$-in. size and less containing an average of 30 per cent. sulphur down to 8-per cent. sulphur content, the ore losing 20 per cent. by weight in roasting and making 5 per cent. of flue dust. The calcines are drawn off into three-ton charge cars which convey them to the reverberatory furnaces immediately in front. The accompanying table gives analyses of ore, calcines and of the resultant slag at the reverberatory furnaces.

ANALYSES OF FINES, CALCINES AND REVERBERATORY SLAG AT CERRO DE PASCO.

Material	SiO_2. Per Cent.	Fe. Per Cent.	Al_2O_3. Per Cent.	Pb. Per Cent.	Zn. Per Cent.	S Per Cent.	Cu. Per Cent.	CaO. Per Cent.
Peña Blanca fines	18.1	20.8	4 6	9.1	5.9	28.8	....	....
Noruga fines	17.4	27.6	3.4	6.0	1.6	33.3	....	....
Resultant calcines	20.2	35.0	3.3	8.5	1.8	9.5	9.0	....
Reverberatory slag	33.0	37.7	2.4	2.8	0.3	0.3	0.39	3.0

The first of the five reverberatory furnaces, 19x60 ft., has been running since April, 1908, treating 3500 tons of calcines monthly. The foundation is of slag. The firebox is 7x18 ft. with an actual grate area of 117 sq.ft. The neck is 4x5 ft. and the rest of the outlet flue is 5.5x7 ft. An undergrate blast at 2.5-oz. pressure is introduced through a 2-ft. pipe from a 36-in. electrically driven fan, running at 720 r.p.m. The ash pit is closed by cast-iron doors. There are four rabble doors on a side, the two nearest the firebox being used to move along the "floaters." The side walls consist of 22½ in. of fire brick faced inside with 9 in. of silica brick.

A 9- to 15-ton charge is dropped into the furnace every two or three hours depending on its running condition. Should there be a short supply of calcines, flue dust may be put in up to three to four tons per charge.

Fettling is done every two months, the job taking 6 to 8 hours. The furnace puts through 110 tons of charge daily, using 30 to 40 tons of coal or an average of 33 per cent., and burns 25 lb. of coal per hour per square foot of grate area. Four tons of charge are concentrated into one of matte with a volatilization of 33 per cent. of the sulphur. The accompanying table gives analyses of the reverberatory products.

ANALYSES OF REVERBERATORY PRODUCTS AT CERRO DE PASCO.

Material.	SiO_2. Per Cent.	FeO. Per Cent.	CaO. Per Cent.	Zn. Per Cent.	Pb. Per Cent.	Al_2O_3. Per Cent.	S. Per Cent.	Cu. Per Cent.	Ag. Oz.
Reverberatory slag	32.0	53.0	0.8	1.2	2.7	4.0	0.3	0.39	0.16
Reverberatory matte	0.4	15.6	....	2.6	16.2	2.8	22.3	36.5	17.0

The converters are of the vertical type, 84 in. in diameter by 168 in. high, and of 10 tons' capacity. There are 12 shells and four stands operated by water under a pressure of 300 lb. per sq.in. Air is used at a pressure of 17 lb. per sq.in. Twelve hundred tons of silicious ore containing 70 per cent. SiO_2 and some gold and silver, and 500 tons of clay are used each month in making 225 relinings, or about 7.5 tons per lining. A lining lasts for about three charges. Two 5-ft. mills, electrically driven, grind and mix the converter-lining material. The clay is obtained from a hill just back of the works.

The present plant includes four blast furnaces, a McDougal roaster, five reverberatory furnaces and a casting machine for the blister copper. A separate dust chamber and stack 21 ft. in diameter and 450 ft. high has been built for the roasting and reverberatory furnaces.

The cost of coal, f.o.b. at the mines, is $1.75 per ton; of coke, including mining, freight, washing and coking, $6 per ton; and of ore, mined and delivered f.o.b. at Cerro de Pasco, $3 per ton. It is estimated that the cost of smelting and converting per lb. of copper produced is 5c. and after deducting the gold and silver values, 8c. at New York.

The smeltery is producing at the rate of 50,000,000 lb. of copper per year, the production of September, 1909, having been over 4,000,000 lb. Between 1000 and 1100 tons of ore are smelted per day in four blast furnaces and four reverberatories. The fifth reverberatory is idle owing to a shortage of calcines of which 100 to 110 tons are treated daily per furnace, with 40 tons of flue dust. The shortage of calcines is due to lack of sufficient McDougal roasters. Additional units are to be erected, eight in all, so that by the summer of 1910, the output will be on the basis of 60,000,000 lb. of copper per year.

The Mount Morgan Smeltery.[1]—The metallurgical works of the Mount Morgan Gold Mining Company, Queensland, Australia, has four blast furnaces, three being in constant operation. The ore treated contains SiO_2, 45 per cent.; Fe, 25; S, 25; Cu, 3.5; and Al_2O_3, 1.5. Iron ore for flux costs $4.44; limestone, $1.60; and coke, $9.50 per ton. The regular daily charge for the furnace is composed of ore, 200 tons; limestone, 100 tons; iron ore, 45 tons; purchased matte and converter slag, 15 tons; a total of 360 tons. This is run with 40 tons or 11.1 per cent. of coke. A matte containing 45 per cent. Cu is produced.

Each blast furnace is nearly 200 in. long and has two tiers of steel water jackets, the lower 7 ft. and the upper 4 ft. high. There are 40 tuyeres set at $9\frac{1}{4}$-in. centers, 3 ft. above the lower edge of the bottom jacket. The forehearth is circular, 12 ft. in diameter by 3 ft. 6 in. deep, and is lined with chrome ore. A smaller guard forehearth takes the flow from the larger one.

For the blast furnaces there are seven motor-driven Connersville

[1] *Eng. and Min. Journ.*, LXXXVII, 802, 838.

blowers, each delivering 10,000 cu.ft. of air per min. at a pressure of 35 oz. per square inch.

There are 64 storage bins in four rows, each bin holding 4000 cu.ft., or about 175 tons. Each of the bins in the front two rows has a sampling chute, 36x10 in., set at the center of the bin. This takes a part of the ore discharging from a car and drops it beneath the bin as a sample.

Hand-charging and hand-feeding are practised.

To sinter the flue dust, which contains Cu, 2.25 per cent. and Au, 0.2 oz. per ton, the McMurtry-Rogers pot-roasting process[1] is used.

Because of the high cost of the ore and the necessity of using much flux and fuel, the cost of producing copper is now 11.2c. per lb. The company has acquired an option on the Many Peaks sulphide mine, 147 miles distant, where the ore can be mined at a cost of $1.50 per ton. This mine will be connected by rail to the present works, and the ore delivered at an estimated cost of $2.05 per ton. The Many Peaks ore contains Fe, 40 per cent.; S, 35.5; Cu, 2.1; SiO_2, 4.6; Al_2O_3, 3.5; CaO, 3.2; Au, 0.0125 oz.; and Ag, 0.3 per ton. It is proposed to use it in connection with the Mount Morgan ore in the ratio of 100,000 tons of the Many Peaks ore to 250,000 tons of the latter, and it is estimated that copper can then be produced at a cost not to exceed 7.4c. per pound.

There are two 5-ton converter stands, having seven shells blown by three electrically driven Parsons turbo-blowers running at 3000 r.p.m. and delivering 3000 cu.ft. of air per min. at a pressure of 15 lb. per sq.in. The charge of 45-per cent. copper matte varies from three tons for the freshly lined converter to six tons on the final blow. The air pressure varies from 5 to 10 lb. per sq.in., and the time of blowing from 1¾ hours at first to 3 hours on the last charge. The shells are lined with silicious ore containing 0.125 oz. Au, which is mixed with a clayey felsite carrying a little black copper sulphide.

The Chillagoe Smeltery.[2]—The works of the Chillagoe Railway and Mines Company is situated at Chillagoe, north Queensland, 140 miles from the port of Cairns. Both lead and copper smelting are done at this plant. These notes refer to the copper department only.

The single 40x160-in. copper-matting furnace has jackets 7 ft. 9 in. high and sixteen 3-in. tuyeres, eight on either side. The upper part of the shaft is of brick. The feed floor is 16 ft. above the tapping floor. The tap jacket, 40x18x6 in., is made of ⅝-in. copper plate, and the usual trapped spout is provided. The rectangular forehearth has five matte tap holes so that if one hole is lost another may be opened.

---

[1] *The Mineral Industry*, XVI, 335.
[2] *Eng. and Min. Journ.*, LXXXVII, 506.

The furnace puts through 180 tons of charge per day, as specified in the subjoined table which gives analyses of the charge and products yielded by the furnace.

ANALYSES OF BLAST FURNACE CHARGE AND PRODUCTS AT THE CHILLAGOE SMELTERY.

Material	Weight.		Cu.		Pb.		SiO_2.		FeO.		CaO.		S.	
	Wet.	Dry.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.
Ruddygore	......	4,000	4.0	160	....	.....	60.0	2,400	9.0	360	....	......	4.0	160
Girofla flux sulphide	......	1,500	1.0	15	7.5	112	12.0	180	37.5	562	....	......	19.2	288
Mungana oxidized	......	1,500	10.0	150	13.0	195	27.5	412	20.0	300	....	......	2.0	30
Queenslander	......	3,000	4.0	120	....	.....	18.0	540	28.0	840	....	......	22.0	660
Leady matte	......	2,000	23.0	460	19.0	380	...	......	25.0	500	....	......	20.0	400
Copper matte	......	900	35.0	315	26.0	234	...	......	15.0	135	....	......	....	......
Lead slag	......	2,000	2.0	40	0.6	12	25.0	500	35.0	700	12.0	240	3.0	60
Limestone	......	3,000	....	......	....	.....	4.0	120	....	......	52.0	1560	....	......
Coke, 6 per cent.	10,000	......	....	......	....	.....	....	......	....	......	....	......	....	......
Total	......	17,900	....	1,260	....	933	....	4,192	....	3,397	....	1,800	....	1,598
Matte	......	2,400	50.0	1,200	13.0	312	....	......	16.0	364	....	......	16.0	384
Slag	......	11,300	0.4	45	3.0	34	....	......	26.0	2,938	19.0	2,147	3.0	339
Total	......	13,700	....	1,245	....	346	....	......	....	3,302	....	2,147	....	723

From the table we deduce the following. (1) The charge gives 60 per cent. of its weight in slag; (2) 95.2 per cent. of the copper is recovered; (3) 33 per cent. of the lead goes into the matte, 63 per cent. is volatilized, and because of high silica, 4 per cent. enters the slag; (4) of the sulphur, 24 per cent. enters the matte, and 55 per cent. is volatilized. With so large a lead loss by volatilization, the silver loss must be high. Altogether, the conditions are peculiar; lead is the cheap metal and is wasted, and the aim is to recover the more valuable copper.

There are two converters, one blowing at a time, since there is not enough blowing capacity for both together. The converter lining is made up of 57 per cent. quartz containing 92 per cent. SiO_2, 29 per cent. of red clay and 14 per cent. of old lining, all tamped in by small pneumatic hammers. The capacity of a converter varies from $1\frac{1}{2}$ to 6 tons, and 11 tons of blister copper can be produced with one lining. The blister copper assays 100 oz. Ag per ton. In blowing, much copper is scorified into the slag which has the following composition; SiO_2, 22.5 per cent.; FeO, 34.5; ZnO, 13.6; Al_2O_3, 5; Cu, 8.5; Pb, 20. The lead in the matte is also largely burned away.

When the converter slags have sufficiently accumulated, a furnace run is made, using 14 per cent. of fuel, the charge being composed of slag, sintered ore, galena, lead dross and limestone. In 24 hours 175 tons of charge can be put through, yielding base bullion, copper matte which goes to the copper-matting furnace, and a lead slag similar to that used in the regular furnace charge. These slags contain 12.5 to 16.5 per cent. ZnO, and hence, need but 25 per cent. silica.

The difficulty of matting these complex ores is due to the fact that if coke is added in excess of 6 per cent. of the charge, lead dross is reduced and collects in the crucible, eventually stopping the furnace.

Smeltery of the O. K. Copper Mines, Ltd.[1]—The works is situated at the O. K. mines, 50 miles north of Mungana, the terminus of the Cairns-Chillagoe Railway, Chillagoe district, Queensland. Both the basic and silicious ore are sulphides, and combined, make a self-fluxing mixture. The basic ore contains SiO_2, 5 to 20 per cent.; FeO, 29 to 50; Al_3O_3, 0 to 2; CaO, 0 to 5; Cu, 2 to 8; and the silicious ore, SiO_2, 40 to 70 per cent.; FeO, 7 to 18; CaO, 1; Cu, 8 to 20.

The furnace, 36x12 in., is 11 ft. from the tuyere level to the feed-floor. It is arranged with a crucible for inside separation, and the matte and slag are tapped intermittently. The charge is composed of both the above-named ores with converter slag, flue dust and limestone. The system of smelting is semi-pyritic, 5 per cent. coke being used. The matte averages 48 per cent. Cu, and the slag contains 40 per cent. SiO_2 and 32 per cent. FeO.

For treating the matte, there is a single converter which is run two shifts out of the three, the matte produced during the night shift being cast into molds and returned to the furnace in the morning.

Flue dust is heaped up in the open and after weathering for three months is mixed in a mill with 25 per cent. of its weight of clayey ore. The mixture is made in briquets by hand and these, after drying, are fed to the furnace.

All supplies are brought 50 miles, traction engines being used for the purpose. Mining costs are $4 per long ton; smelting costs $6 per ton; and converting costs, 9c. per lb. of copper produced. With average ores containing 8½ per cent. Cu, blister copper can be produced for 9.2c. per lb. at the works, or for 10.3c. per lb. on the wharf at Cairns.

This plant is a good example of a small-scale smelting operation carried on at mines remote from both railroads and ports.

Mount Molloy Smeltery.[2]—This plant is situated at Molloy, 20 miles from Biboora, a station of the Cairns-Chillagoe Railway, Chillagoe district, Queensland. It possesses a single water-jacketed blast furnace 90x36 in. at the tuyeres, and 10 ft. 6 in. from tuyere level to feed floor. The furnace discharges to a reverberatory furnace where the matte is separated and stored until it is wanted at the converter. The output is sufficient to keep the converter in action only two shifts out of three in 24 hours, the matte produced during the night shift being stored until

---

[1] *Eng. and Min. Journ.*, LXXXVII, 606.
[2] *Ibid*, LXXXVII, 1125.

morning. G. W. Williams, who has described this plant, questions whether this method is as inexpensive as the method adopted at the O. K. smeltery, where the matte produced on the night shift is cast into cakes and put through the furnace during the day, thus doing away with the need of a reverberatory. The reverberatory furnace has, on the other hand, the advantage that it gives time for the thorough settling out of the matte from the slag, thus ensuring cleaner work.

The blast-furnace charge of 130 tons per day consists of chalcopyrite and pyrite ores, flue dust, converter slag, iron ore and limestone, and is run with 8.5 per cent. of coke, yielding a matte with 50 per cent. Cu, and a slag containing SiO_2, 40 per cent; FeO, 30.4; CaO, 9.9; ZnO, 6.5; Al_2O_3, 8; MgO, 3.2; S, 0.7; and Cu, 0.43.

Port Kembla Smelting and Refining Works.[1]—This plant of the Electrolytic Smelting and Refining Company of Australia is situated at Port Kembla, 50 miles south of Sidney, N. S. W. A general custom business in the treatment of copper ores and mattes is carried on.

The reverberatory furnaces, 18x35 ft., having capacities of 60 tons each, are lined with chrome iron ore. There are two converter stands, having shells 90x126 in., with a capacity of 25 tons of blister copper daily. This copper averages 99.4 per cent. Cu, 10 to 20 oz. Ag, and 12 to 15 oz. Au per ton. The electrolytic refinery contains 360 vats each 10 ft. long, 3 ft. 6 in. wide, and 3 ft. deep, and has a capacity of 35 tons per day. The gold and silver recovered from the slime are parted electrolytically. The cathodes assay 99.85 per cent. Cu, and the wire bars, remelted and refined from them, carry 99.96 per cent. copper.

The Wallaroo & Montana Smeltery.[2]—The plant of the Wallaroo & Moonta Mining and Smelting Company is situated at Wallaroo Bay, South Australia. Fine material consisting of a mixture of fine ore and concentrates, is desulphurized and sintered by pot-roasting with the elimination of 75 per cent. of the sulphur. This sintered material, together with raw ore, limestone and iron ore, is smelted in two blast furnaces yielding a matte with 45 to 50 per cent. Cu, and a slag carrying 0.5 per cent. Cu. The cost of smelting and refining averages 4¼c. per ℔. of copper produced. For the year 1907 the cost, including all production and selling costs, was 14.7c. per ℔. For the year 1908 this was reduced to 12.3c. per ℔., the crude ore averaging 4 per cent. Cu. In 1907, 55,000 tons of concentrates carrying 10 per cent. Cu were produced from 187,000 tons of crude ore running 3.8 per cent. Cu, i.e., a recovery of nearly 78 per cent. was effected in the concentration.

[1] *Aust. Min. and Eng. Rev.*, Jan. 5, 1909.
[2] *Eng. and Min. Journ.*, LXXXVIII, 59; *The Mineral Industry*, XVI, 219, 344.

Alloys of Copper.

Influence of Bismuth on Copper.[1]—Cast copper containing as high as 0.18 per cent. bismuth is stronger than pure copper, the bismuth here presenting the same effect as arsenic and antimony, its associates in the grouping according to the periodic law.

For copper to be rolled, the allowable percentage of bismuth is that which will not affect its malleability and ductility. This limit is found to be less than 0.005 per cent. for metal to be rolled either hot or cold. It is thought that so small a proportion of bismuth will not appreciably lessen the conductivity of the copper.[2]

Influence of Arsenic and Antimony on Copper.[3]—H. S. Hiorns and S. Lamb have investigated the influence of arsenic and antimony up to 3.5 per cent. upon pure copper with which these metals have been alloyed. They give a summary of what has been learned on the subject with respect to physical qualities (but not conductivity) as follows:

Haupe, in 1892, found that 0.5 per cent. arsenic produces no bad results and that even when the percentage was increased to 1 per cent. only a slight degree of hot-shortness but no cold-shortness could be noticed. He found that copper with 0.8 per cent. arsenic could be drawn into the finest wire. Stahl, in 1886, stated that a small percentage of arsenic prevents copper from becoming porous. Hiorns, in 1906, showed that copper with arsenic up to 0.4 per cent. was very malleable when cold; that with 0.2 per cent. each of arsenic and antimony the same is true; and that arsenic in the presence of antimony makes the copper more malleable than it is with antimony alone, though antimony when not above 0.2 per cent. only slightly impairs the malleability of copper. He adds that arsenic in copper is highly beneficial because it deoxidizes cuprous cxide which tends to destroy the malleability of the copper. Johnson, in 1906, stated that cast copper with 0.5 per cent. arsenic has a tensile strength of 10 long tons per sq.in. and a 24-per cent. elongation. After forging, the tensile strength was raised to 12.75 tons, and the elongation to 35 per cent. Upon rolling, the tensile strength became 14 tons and the elongation 48 per cent., and finally, upon being highly wrought and cold drawn, the tensile strength of the same cast copper was raised to 15.9 tons, and the elongation varied from 24 to 50 per cent., while the specific gravity was increased from 8.83 for copper in the cast state to 8.896 when the metal was wrought.

H. S. Hiorns and S. Lamb prepared alloys consisting of pure electrolytic copper and arsenic or antimony in quantities varying from 0.05

[1] *Trans.*, A. I. M. E., 1909, 865.
[2] *The Mineral Industry*, XIV, 161, Fig. 19.
[3] *Journ. Soc. Chem. Ind.*, XXVIII, 451; *The Mineral Industry*, XIV, 161; *Trans.*, A. I. M. E., XXXVI, 18.

up to 3.5 per cent. These alloys were drawn into wires 0.0325 in. in diameter and were tested for conductivity with results as shown by Fig. 4.

In the discussion of the paper of these investigators, F. Platten stated that when arsenious oxide was added to copper its effect was practically negligible, but that if metallic arsenic were added to the copper in the furnace, there was an increase in tensile strength. This would seem to indicate that the metallic arsenic neutralized the cuprous oxide. Engineers specify a content of 0.3 to 0.5 per cent. arsenic for copper to be used for locomotive plates and tubes. E. A. Lewis said his experience

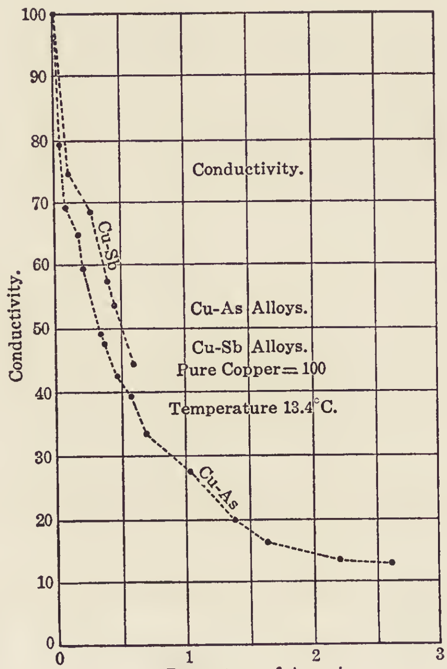


Fig. 4

with arsenic copper was that it always contained oxygen and nearly always as much as non-arsenical copper, and it seemed that the arsenic did not remove the oxygen. D. M. Levy suggested that further investigation was needed to show the effect of increasing quantities of oxygen on the series of alloys above specified. Some years ago a paper was published showing that the effect of arsenic on copper was not as great if there was a certain quantity of lead present. Mr. Levy thought that the presence of arsenic and lead was more desirable than the presence of either alone. F. Johnson stated that the chief advantages of arsenic in copper were that it raised the temperature at which the copper became annealed, that it made the copper tougher at all temperatures, and that it considerably modified the effects of bismuth.

A. H. Hiorns, in replying to the above remarks, stated that he had come to the conclusion that 0.215 per cent. arsenic in copper was a critical point, and that above and below this point there was a different action. He was of the opinion that with above this amount a blue compound, Cu_3As, containing 28.34 per cent. copper began to form; that this compound was in solid solution under certain circumstances, and that in other circumstances it separated out. He found that with as low as 0.22 per cent. arsenic and upon very slow cooling there was a slight separation of the compound. He though that the properties of the copper would vary according as this compound was in a free state or in a state of solid solution and that it was not safe to introduce more than 0.2 per cent. of arsenic into copper. He found that with between 0.5 and 1 per cent. of arsenic the malleability seemed to diminish, but with over 1 per cent. and up to 2 and 3 per cent. arsenic the copper rolled perfectly and was harder than pure copper. With less than 0.5 per cent. of arsenic, the copper should be less malleable when cooled slowly than when cooled quickly. With a certain quantity of arsenic introduced into copper, the first small portions appear to act by reducing the cuprous oxide, the remainder retaining its metallic form and toughening the copper. It also seems that arsenic has the valuable quality of enabling copper to resist the corrosive effect of firebox gases as well as mechanical wear. Mr. Hiorns believed that copper with a suitable proportion of arsenic acted better in these respects and was better suited for resisting high temperatures than any other alloy of the metal.

Influence of Nickel on Copper.[1]—Manufacturers of copper plates call for a copper with a tensile strength of 14 tons per sq.in., an elongation of 38 per cent., and a reduction of area of 50 per cent. Arsenic up to 0.30 to 0.45 per cent. increases the tensile strength without affecting the elongation, average figures being 14 to 15 tons per sq.in. tensile strength, 33 to 40 per cent. elongation, 47 to 62 per cent. reduction of area. It also increases the working qualities of the copper and prevents the prejudicial effects of small quantities of bismuth and other embrittelers. With above 0.45 per cent. arsenic the tensile strength still increases, but at the expense of increased elongation.

Nickel increases the tensile strength of copper as it does that of iron without affecting the other properties of the metal. The average of a large number of determinations, when several tenths of one per cent. of nickel had been added to the copper, gave a tensile strength of 14 to 15

[6] W. Stahl, *Metallurgie* Oct. 8, 1909.

tons, an elongation of 39 to 46 per cent., and a reduction of area of 50 to 67 per cent. These alloys of nickel with copper stand the effects of working and of large variations in temperature better than the corresponding arsenic-copper alloys.

Smelting Costs.

Cost of Treating "Mineral" at the Lake Superior Smelting Works.[1] The plant at Dollar Bay, Mich., treats the "mineral" or concentrates from the ore-dressing mills of the Tamarack, Osceola, Ahmeek, and Isle Royale mining companies, and also some cathode copper. The concentrates, averaging 60 per cent. Cu, are melted in reverberatory furnaces, yielding copper and a slag formed from the self-fluxing gangue. The slag contains much copper, mostly in metallic form, and is treated in a blast furnace.

A suit instituted by the Bigelow interests against the Calumet & Hecla Company, resulted in published sworn testimony from which was obtained the following costs of treatment:

During the year ended April 30, 1906, there were smelted in reverberatory furnaces, 41,176.88 tons of "mineral" from which there were produced 12,515.34 tons of slag (30 per cent. of the "mineral"). This reverberatory slag was smelted with 18 per cent. limestone and 4.3 per cent. iron ore using 15 per cent. fuel, in a blast furnace or cupola, and yielded slag containing 1 per cent. Cu which was wasted, and 5374.81 tons of ingots of blister copper (cupola blocks), containing about 94 per cent. Cu. This indicated that the slag must have carried 42 per cent. Cu, or that about 21 per cent. of the copper in the "mineral" found its way into the reverberatory slag. Experience at the Michigan smeltery, where mass copper is added to the charge, indicates that such excess of metallic copper, melting and raining down through the charge, effectually cleans the slag. The cupola blocks were remelted and refined in reverberatory furnaces so that the total mineral treated in them was 46,551.69 short tons containing 55,526,088 lb. of copper or nearly 60 per cent. by weight of the "mineral" treated.

Costs of treating concentrates or "mineral" during an entire year and for the month of April, 1906, are given in the tables on following page.

In April, 1906, the amount of "mineral" and cathode copper supplied by the various mines and treated in reverberatories was as follows: Tamarack, 537.24 tons; Osceola, 1109.43; Ahmeek, 113.16; Isle Royale, 172.94; Boston & Montana cathodes, 1101.88; also cupola blocks from the blast furnace, 146.76 tons; making a total of 3181.42 tons. The "min-

[1] *Min. and Sci. Press*, XCVIII, 592.

COST OF TREATING "MINERAL" OR CONCENTRATES FOR ONE YEAR.

Items of Expense.	Cost For Year.	Cost. Per Ton.
Reverberatory Expense—Operating	$195,144.61	$4.741
Miscellaneous	43,408.84	1.055
Construction	15,664.74	0.380
Blast-furnace Expense—Operating	32,623.44	0.790
Miscellaneous	13,460.59	0.327
Total cost	$300,302.21	$7.293

COST OF TREATING "MINERAL" OR CONCENTRATES FOR APRIL, 1906.

Items of Expense.	Cost Per Month.	Cost Per Ton.
Reverberatory Expense.		
Operating—Labor	$ 5,991.82	....
Supplies (including fuel)	4,728.51	....
Power	329.69	....
Repairs	1,598.71	....
	$12,648.73	$4.168
Other expense $986.33	....	....
Miscellaneous 1,899.30	2,885.63	0.951
Construction	2,713.04	0.893
Blast-furnace Expense.	$18,247.40	$6.012
Operating—Labor $495.05		
Supplies (including fuel) 1,476.54		
Power 242.22	2,215.81	0.731
Other expense—Labor $612.55		
Miscellaneous 474.82	1,087.37	0.358
For 3034.66 tons mineral	$21,550.58	$7.101

eral'' from each mine was treated separately in its own reverberatory furnace, except that at that time cathodes were added to the furnace charge and melted down with the ''mineral,'' the resultant copper being marked with the brand of that particular mine; but Ahmeek copper went into Osceola molds. The corresponding reverberatory slags, were Tamarack, 319.09 tons; Osceola, 343.09; Ahmeek, 41.74; a total of 703.92 tons.

The miscellaneous expense mentioned in the above table is distributed, four-fifths to the reverberatory ($1899.30) and one-fifth to the blast furnace ($474.82) and its items are made up of office supplies, $98.09; general expense (cleaning yard, telegrams, express, telephone, electric light, portions of general office expense at Houghton and Boston, taxes, insurance, and a share of engine expense for power), $1156.18, yard and office labor, $1119.85; making a total of $2374.12.

Summarizing the above costs when treating 3034.66 tons of "mineral," we find for April, 1906, the reverberatory expense and construction to be $18,247.40, and the blast-furnace expense to be $3,293.18, a total of $21,640.58 or $7.101 per ton of "mineral." In the blast furnace 776.47 tons of slag were smelted at a cost of $4.241 per ton.

The charges made by the smelting company for treating this "mineral" and the Boston & Montana cathodes are given in the accompanying table:

SMELTING CHARGES FOR TREATING "MINERAL" AND CATHODES.

Material.	Tons.	Smelting Charge Per Ton.	Total Charges.
Tamarack "mineral"............	537.24	$7.16	$3,846.64
Osceola "mineral"..............	1,109.43	8.75	9,707.51
Ahmeek "mineral"..............	113.16	8.75	990.15
Isle Royale "mineral"...........	172.94	7.16	1,238.25
B. & M. cathodes...............	1,101.88	4.00	4.403.52
Total smelting charges for April, 1906...............			$20,230.07

Comparing the total cost with the total charges indicates a loss of $1320.51 for the month.

A Study of Practicable Copper Slags.*

By Edward Dyer Peters.

It is a frequent saying among practising copper smelters that metallurgical writers give a vast amount of general information about the composition of copper slags without pointing out specifically the type of slag best suited to given conditions or without discussing frankly and precisely the practicable limits to which silica, lime, alumina, magnesia, zinc, etc., may be pushed.

The present paper is an attempt to fill this gap so far as may be practicable in such limited space; and in order to accomplish the purpose at all, it must eliminate theoretical questions, and must confine itself almost exclusively to practical conditions, speaking also with more positiveness than would be becoming in a more complete essay. It must also omit the important question of the amount of copper carried by the various slags, excepting merely to mention it in connection with the analysis of the slag under consideration. It is the more necessary to omit discussion on this point because the subject is a complicated one, standing in close connection with various other influences besides the mere chemical composition of the slag. The copper content of every slag

* Note: This paper is an abstract prepared by Doctor Peters of portions of the chapter on slags from the new book he is now writing to replace his "Modern Copper Smelting."—Editor.

produced from the smelting of sulphide ores is made up of at least three separate and distinct portions: (a) The copper contained in prills of matte which are suspended mechanically in the slag; (b) the copper existing in oxidized form and consisting usually both of copper oxides in solution and of copper silicate; (c) the copper actually dissolved in the slag as cuprous sulphide. The loss denominated (a) calls for a thinner or lighter slag, or an improvement in the settling department. The loss (b) calls for increased reduction in the furnace and possibly a stronger base. The loss (c) brings up the difficult and little understood question of the mutual solubility of sulphides and silicates, with special reference to the comparative solubility of FeS and Cu_2S under differing conditions. It is evident, therefore, that this subject would be out of place in the simple study of slags which is the object of this paper.

The classification of slags according to their silicate degree appears to be suitable for purposes of description, and the employment of the oxygen ratio between the silica side and the base side of the slag seems to me the most convenient way of expressing this degree. In order to effect this purpose clearly, it is easier to go back temporarily to the older chemical nomenclature and to regard our slag as a salt of silica and a base, in which the silica is expressed as SiO_2 and the base is regarded as the oxide of a metal; for instance, instead of expressing ferrous bi-silicate as $FeSiO_3$ it is written FeO,SiO_2, thus enabling us to dissect the salt, placing the silica on the one side and the oxidized metal (base) on the other.

The list of slag-forming substances which demand serious consideration is short and may be limited to the single acid constituent, silica; and to the bases, ferrous oxide, manganous oxide, zinc oxide, lime, magnesia, baryta, and alumina (exceptionally, soda and potash). As manganese has nearly the same atomic weight as iron, and as its behavior as a slag-forming substance is practically identical with that of iron, it may be neglected as a separate metal and simply added to the iron content of the slag or ore.[1] There remain, therefore, for more extended consideration, the following slag-forming substances: ferrous oxide, zinc oxide, lime, magnesia, baryta and alumina.

As the quality of fusibility is one of the main issues in considering the suitableness of slags, it is important to bear in mind that the formation temperature of a given slag bears no regular or definite relation to the degree of temperature that may be necessary to render the same slag

[1] From 1882 to 1884, John A. Church made blast-furnace slags at Tombstone, Arizona, which averaged fully 40 per cent. manganous oxide. They were satisfactory, and differed but little from iron slags. *Trans.*, A. I. M. E., XV, 612. In 1884, in Butte, Montana, I substituted, temporarily, manganese ores for roasted pyrite concentrates until my reverberatory slag contained about 22 per cent. MnO. No appreciable difference was noted either in the fusibility of the slag or in its values in copper gold or silver.

sufficiently liquid to flow properly or to be suitable for the purposes of the smelter.

Speaking primarily of blast-furnace work, the object of subjecting a copper ore to the operation of smelting comprises several distinct purposes of which two fundamental ones are: (a) to render the entire mass so liquid that the matte globules may settle out of the slag, and (b) that the slag may flow out of the furnace as it is formed and thus permit the continuous descent of the column of charge.

In the active combustion zone of the blast furnace a temperature of 1500 deg. C. may easily be attained throughout a limited area just above the tuyeres. According to Hofman's experiments[1] a slag, for example, a tri-silicate consisting of approximately 58 per cent. SiO_2, 28 per cent. FeO, and 14 per cent. CaO, is formed at the moderate temperature of 1130 deg. C., and might, therefore, be considered to possess an ample margin of safety; yet such a slag would freeze up any blast furnace unless run with an abnormal amount of fuel as well as with extraordinary and harassing precautions. A slag of this composition is so viscid that even a temperature of 1400 deg. C. is none too high to keep it properly fluid; and while this temperature may be maintained at a single limited horizon just above the tuyeres, it drops rapidly after this point is passed and is not maintained long enough to keep the slag sufficiently superheated to flow properly.

A peculiar and exceptional illustration of this discrepancy between the formation temperature of a slag and its flowing temperature is pointed out by Dr. Carpenter[2] in connection with smelting the Cripple Creek gold ores at Florence, Colorado. These ores have a feldspathic gangue and thus contain a considerable amount of soda and potash. By crucible experiments he obtained good results from a mixture yielding slags of about the following compositions: SiO_2, 50 per cent.; FeO, 10; Al_2O_3, 14.5; CaO, 10.5; MgO, 5.5; K_2O, 7.1; Na_2O, 1.6; total, 99.2. These slags when superheated were thin and fluid, but after passing the tuyere zone chilled rapidly and became so viscous that the furnace was soon frozen. The slag formed at too low a temperature and escaped from the focus of the furnace before it was sufficiently superheated to remain liquid. The obvious remedy was to raise the formation temperature to a point where it would more nearly correspond with the fluidity temperature. The only available base for this purpose at Florence was MgO; and by the judicious use of this substance, Dr. Carpenter produced slag that had a higher formation temperature and was thoroughly fluid when

---

[1] *Trans.*, A. I. M. E., XXIX, 682. Most of the succeeding temperature determinations are taken from Hofman's tables.
[2] *Ibid*, XXX, 1129.

it left the furnace. While this is an extreme case, it is highly instructive as a means of focusing our attention upon the often neglected fact that the formation temperature of a slag is not a sufficient criterion of its suitableness.

In spite of the obscuring influence of the highly reducing atmosphere that results from burning coke in the blast furnace with moderate blast, this type of furnace offers a clearer field than the reverberatory for the preliminary study of slag formation. The reason for this is that, in the reverberatory furnace, slag formation is much less spontaneous than in the blast furnace. The former type of furnace may be regarded as an immense crucible in which any reasonably suitable ingredients, under the influence of a sufficient degree of heat, must melt into a liquid condition, because they remain lying passively in contact upon the hearth of the furnace, exposed to a steadily rising heat which passes through all the gradations corresponding to the formation temperatures of an almost infinite variety of silicates, until eventually various unwilling constituents are, as one might say, bullied into forming some kind of mutual combination or solution, and becoming a more or less homogeneous liquid. The action in the blast furnace affords much freer scope for the affinities of the various constituents to assert themselves. This freedom of action constitutes the most characteristic feature of true pyrite smelting; but even in the coke-burning blast furnace the laws of individual selectiveness assert themselves in a manner that is quite striking to those who will take the trouble to study them.

The blast furnace may be regarded primarily as a great liquating apparatus in which the most fusible constituents of the charge melt first, escape from their more refractory companions, pass the ordeal of the focus (horizon of most intense combustion) where they exert a most important influence upon the still unfused skeleton of charge, and eventually reach the neutral area below the tuyeres where, in spite of more or less mixing and mutual solution, they seldom undergo any marked change in the chemical composition of their fundamental types. This fact becomes quite evident when one considers that the fiercest intensity of their affinities has been developed (and, under normal conditions, satisfied) under the culminating temperature of the focus. The greater includes the lesser, and affinities which have satisfied themselves at a temperature of 1400 deg. C. and upward are not likely to undergo much alteration at the lower heat of the infra-tuyere zone.

The operation of liquation commonly presupposes some sort of support upon which the liquating material may rest while the fusible portion drains away from the more refractory part. In ordinary blast-furnace work this support is furnished by the yet unconsumed fragments of glowing coke through whose interstices the molten globules may be seen trickling and dropping as they are liquated from the ore column just above this point. These drops consist of both matte and slag, and the difference between these two substances can easily be detected by the trained eye. The matte does not concern the present inquiry, but the slag is of the greatest importance and interest, because it is changing its composition constantly in its downward course and arrives at the crucible as a very different silicate from what it was when first formed and liquated from the charge.

In the true pyrite furnace the foundation which supports the ore column is even more obvious than in the coke-burning furnace. Instead of fragments of glowing coke, interpersed with the larger and more refractory lumps of ore, we have a tolerably firm and permanent silicious skeleton (pierced, to be sure, by innumerable channels and cavities) wasting constantly away as it is dissolved by the ferrous oxide which flashes into existence in the bessemer slot of the shaft under the combined influence upon the pyrite of the blast and the propinquity of white-hot silica, but as constantly renewing itself from the still uncombined silica which is settling down upon it from above. So solid is this silicious skeleton that, even in the most actively running pyrite furnace, the tuyeres are likely to remain absolutely dark and a bar may be driven deep into the mass without encountering either liquid slag or great heat. This condition means simply that, owing to the powerful blast and the absence of all coke, the active zone of the pyrite furnace lies at a considerable distance above the tuyere level. The bessemerizing effect is obtained by the impingement of the blast upon the liquated sulphide as it showers from above into the bessemer slot, while the true smelting, or slag-forming, results from the action of the oxidized pyrite upon the silicious mass which has accumulated near the bottom of the shaft on account of lack of bases to serve as flux for it.

If more quartz is fed into the furnace than can be digested by the FeO formed at the focus, the shaft will gradualy choke up with unfused silica. If, on the contrary, too little quartz is provided to satisfy the FeO which is capable of being produced by the action of the blast upon the pyrite, low-grade matte, over-fire, and eventually, thick magnetic-iron slags will result, to be followed in time by the freezing of the furnace.

In practice, these striking phenomena, peculiar to true pyrite smelting, are seldom seen in their fullest development, for the simple reason that a charge consisting solely of pyrite and free silica is almost never smelted. Both commercial and metallurgical conditions require the presence of a certain proportion of earthy bases, and as the amount of these inert constituents is increased and the heat evolved by the combustion of the pyrite has to be divided amongst them, an adition of carbonaceous fuel becomes necessary. Both of the above factors tend to obscure the conditions pictured as characteristic of true pyrite smelting.

This much of introduction seems essential in considering the formation and behavior of slags, because it emphasizes the important difference between reaction smelting and simple fusion smelting.

By reaction smelting I mean the sort of smelting which results from the coming together of substances which are not already chemically combined, and whose affinities are roused by the conditions obtaining within the furnace. True pyrite smelting is an extreme example of reaction smelting. Less striking, but equally true, instances of reaction smelting are the ordinary charges of silicious ore, pyrite, and limestone so often employed in the common partial pyrite smelting of today. The blast-furnace work at Anaconda and Great Falls, Montana, is a familiar example of this practice.

By simple fusion smelting I mean the mere melting of mineral subsances which are already more or less suitable combinations of silica and bases, and which demand little more than an increase of temperature and the opportunity to pick up a few per cent. more of iron or lime to form a proper slag. A typical case of this kind of smelting may be found at Mansfeld, Prussia, where the well-known cupriferous slates consist mainly of suitable proportions of silica, alumina, lime, magnesia, and iron mostly already combined, and undergo a simple fusion with a minimum of reactions during the process.

Naturally, the mere fusion of already-formed silicates which require only a few per cent. of reactionary iron or lime to produce a suitable slag is a much simpler matter than the creation of a new silicate out of three or four independent, uncombined substances. Apart from the fact that propinquity plays a vital part in the rapidity and thoroughness of smelting reactions, the actual time required to produce the desired combination is of no small importance in the smelting operation, whilst the effect of quite violent endothermic and exothermic reactions upon the distribution of heat in the shaft—at one time tending to cool the smelting zone; still oftener to heat the upper regions of the shaft, producing the fatal over-fire which is, perhaps, the most disastrous feature in partial pyrite smelting—encourages irregularities, wastes time and heat, and in a word, makes the operation of reaction smelting a much more delicate, difficult, and tedious process than its simpler prototype.

In beginning the study of the composition and characteristics of actual slags, accompanied always by a careful consideration of their silicate degree, we are confronted by a difficulty which, in the present state of our knowledge, is insurmountable. As it cannot be removed, there is nothing to do but to go around it, leaving it as an annoying obstacle in a path which would otherwise be reasonably smooth. This obstacle is the behavior of alumina in the formation of ordinary copper slags. Does this substance play the part of a base or of an acid; or is it merely dissolved in the general slag menstruum? As the last of these three hypotheses is plainly untenable for slags above about 35 per cent. silica, and as I know of no positive evidence for its correctness even in the less silicious charge, namely, that "when the alumina goes u pthe silica theories can boast of adherents whose opinions and arguments are too weighty to be lightly dismissed. There is a considerable amount of valuable, though scattered, literature upon the subject, but the most modern and, to me, the most interesting example is Mr. Shelby's recent paper.[1] He maintains that, in the class of slags now under consideration, "alumina is neither a base nor a foreign substance carried in the slag menstruum, but is always present as an active acid; and that when one may seemingly be replacing an undisputed base with this oxide, and thereby causing it to assume the role of a base, he is simply altering the silicate degree of the slag." The fact that, when thus allowing alumina to figure as an acid, we raise some of our well-known slags, such as many of the classic Mansfeld slags, to the degree of tri-silicate and even higher, does not alter his opinion, for reasons which would require too much space to elucidate.

Personally, while not yet ready to go as far as either Shelby or Bretherton[2] in this matter, I am entirely in sympathy with most of their views, and find in them the only satisfactory explanation for the well-known dictum of the practical smelter when dealing with moderately silicious charge, namely, that "when the alumina goes up the silica must go down." If this precaution be not taken the slag will either show floaters of unfluxed silica, or, if homogeneous, will draw into threads like glass, indicating a condition which will soon make trouble. In spite of the probability of this theory I do not feel that it can yet be accepted as absolute truth. We should be the more cautious in adopting it without further research because any attempt to classify slags on this basis would overturn our ordinarily received ideas on slag formation and silicate degree in a manner that would be confusing to practical metal-

[1] "Alumina in Copper Blast-furnace Slags," *Eng. and Min. Journ.*, LXXXVI, 270.
Ibid., LXXXVI, 483.

lurgists who will require time and testimony before they will be willing to conceive of tri- and quadri-silicates as practicable slags. I shall, in the present case, continue to class alumina as a base.

Beginning now with the consideration of actual commercial copper slags, we may pass rapidly over the ordinary types which constitute the product of the majority of the world's furnaces.

As silica is to be our only acid, the acid side of the slag is easily disposed of from a qualitative standpoint.[1] The most common type of slag is one not far removed from a sesqui-silicate, high in iron, and in which the silica, ferrous oxide, and lime form about 90 per cent. of the total weight, while the remaining 10 per cent. is made up of about eight per cent. of Al_2O_3, MgO, MnO, BaO, ZnO, and K_2O, with two per cent. of CuO, Cu_2O, Cu_2S, FeS, BaS, CaS, etc. The last 2 per cent. may be omitted as having practically no bearing upon the points under consideration. The 8 per cent. of miscellaneous bases, however, possess an importance distinctly out of proportion to their actual weight. This arises not only from the fact of the general lower formation temperature of a polybasic slag, but even more from the remarkable increase in liquidity and flowing capacity, whereby no such excessive superheating is required as in the case of an equivalent slag, poorer in its variety of bases. With the large furnaces and powerful slag flow of the present day, this quality is neither so apparent nor so important as it was with the small slow-running furnaces of a former period. Next to temperature, volume is the important factor for comfortable smelting, and for a peaceful settler.

The type of slag to which I am now referring is too familiar to demand much consideration at present. It may vary from an almost pure ferrous silicate, with scarcely any CaO or other bases, to a silicate so poor in iron that it falls into the class of the more unusual slags which it is the province of this paper to examine particularly.

Referring first to the lowest silica slags which it is practicable to make with FeO as the sole base, and assuming that the total silica-iron content of any commercial slag is not likely to exceed 95 per cent., I think we may say that the uni-silicate (2FeO, SiO_2) is about as low as it is profitable to go in silica. Such slags are feasible, but have so high a specific gravity and so strong a solvent power for sulphides that it is difficult to make them low in copper; they also have a strong tendency to chill in the large settlers needed for a good separation. Perhaps the

[1] A single rather rare exception may be noted. Titanic acid, usually introduced into the copper charge in the shape of titaniferous iron ores used as flux, may demand occasional consideration, especially when considering new enterprises. It behaves as an acid and may be figured to replace silica as follows: one part TiO_2 replaces three quarter parts SiO_2. Doctor Rossi's slags in making iron from titaniferous ores contained SiO_2, 16.63 per cent.; TiO_2, 34.66; CaO, 26.03; MgO, 10.27; FeO, 7.12; Al_2O_3, 7.26. They were fusible and satisfactory. *Iron Age*, Feb. 6 and 20, 1896.

most important point to note in relation to these somewhat basic slags is that they have a rather high formation temperature (1270 deg. C. for the pure ferrous uni-silicate) which falls rapidly as the slag is made more silicious, becoming 1140 deg. C. for the 3:4 silicate with 35.7 per cent. silica; 1120 deg. C. for the sesqui-silicate with 38.5 per cent. silica; and only 1110 deg. C. for the bi-silicate with 45.45 per cent. silica.

This lowering of the formation temperature as the silica content increases is not always fully realized, the reason being twofold; first, the low silica slags run so thin and fiery that they give the impression of having a low formation temperature; secondly, the high silica slags, though having a lower formation temperature, have a materially higher flowing temperature; and by the time they reach the bi-silicate degree become so slow and viscous that they hamper and retard the process to an extent that is frequently prohibitive. The practical smelter derives little satisfaction from the fact that experiments inform him that his slag has a low formation temperature when this very slag is so slow and thick that his tonnage is cut in halves and his tuyeres require barring every few hours. It is at this point that we must call in the aid of experience.

In practice a nearly pure (95 per cent.) ferrous silicate slag will run the fastest, maintain the cleanest furnace, and yield the most profit, other conditions being equal, when it contains about 38 per cent. silica and 62 per cent. ferrous oxide. This reduced to a basis of 100 per cent. would indicate a slag of about the following composition: SiO_2, 36 per cent.; FeO, 59; miscellaneous bases, 5. This is about a 3 : 4 silicate. Any considerable addition of silica to this slag, although often advantageous for commercial reasons, lessens its flow and tends to diminish the rapidity and extreme comfort of the smelting conditions. So true is this in practice that I have rarely seen circumstances where it paid to increase the silica content of such a slag beyond 41 per cent., yielding a slag of about the following composition; SiO_2, 41 per cent.; FeO, 54; miscellaneous bases, 5. Beyond this point it is nearly always more profitable to add a barren basic flux than to submit to the increased consumption of coke, decreased tonnage, crusted tuyeres, chilled settlers, and various other evils which begin to assert themselves with a nearly pure ferrous slag running above 41 per cent. silica.

True pyrite smelting offers the most suitable and instructive example of the fact that the formation temperature of ferrous silicates rises as the slag becomes higher in iron and lower in silica. Any extended examination of this rare and highly specialized branch of the art is impossible in a brief paper, and I shall merely call attention to the results obtained at Mount Lyell, a few years since, when Sticht changed his practice from a comparatively low ore column and moderate volume of heated blast, to a higher column and a powerful cold blast.[1] The aim of the Mount Lyell process was to smelt the maximum quantity of massive cupriferous pyrite with as little addition as possible of the barren silica which at that time was the only acid flux. This means, of course, that they desired to flux as much iron as they could with a minimum amount of silica, and thus produce as basic a slag as possible, at the same time obtaining as high a concentration of the matte as conditions would permit.

We know that, other things being equal, a furnace will produce just that particular type of slag which has a formation temperature corresponding to the degree of heat which is being attained in its smelting zone. While this is a general law, and therefore equally applicable to all furnaces, processes, and situations, the conditions obtaining in true pyrite smelting happen to be such that the manifestations of this law are peculiarly untrammeled; hence the practical result is so brilliant and characteristic that it has become proverbial to say that "the pyrite furnace chooses its own slag."

The charge at Mount Lyell contained about 16 per cent. of earthy bases and under the hot-blast régime chose to select a slag with a silicate degree of about 4:3. This slag contained 37 per cent. silica and had a formation temperature a little below 1100 deg. C. The concentration was only seven into one, and the low-grade matte produced required a second oxidizing smelting to fit it for the converters. As soon as the hot blast was replaced by a much greater volume of cold wind, the thermal conditions in the furnace were improved to a remarkable extent. The heat was less diffused and the more concentrated focus attained a temperature which permitted, or rather demanded, the formation of a less fusible and more ferruginous slag. The silicate degree dropped to the uni-silicate level, the silica falling to between 30 and 31 per cent., while the grade of the matte at once corresponded to the more thorough combustion of the pyrite. About 20 tons of ore were smelted into one ton of matte, this product now being rich enough for the converters without any intermediate concentration smelting.

It is almost impossible to find any modern, authenticated, long-continued examples of nearly pure iron-silica slags; but I know from my own experience in early days, when running small blast furnaces on a mixture consisting of rich silver ores in an almost pure quartz gangue and roasted massive gold-bearing pyrite, that I always had the least trouble and the biggest tonnage when the silica of my slag was somewhere between 35 and 37 per cent.; and that, if it ever rose above

---

[1] Edward D. Peters, "Principles of Copper Smelting," 254 et seq.

40 per cent. the foreman would begin to complain of slow smelting and dark tuyeres. Large furnaces and modern conditions may tend to raise the profitable silica limit 2 or 3 per cent., but the same general rule will always hold good.[1] As these almost pure iron-silica slags are exceedingly rare, it will be better to defer any generalizations on the subject until we have modified them sufficiently to conform more nearly to the ordinary conditions which confront the metallurgist.

The great copper smelters of the world are usually supplied with a large amount of silicious sulphide ore and also with considerable quantities of pyritic concentrates. This latter material is seldom so useful for fluxing purposes as it might casually appear, for the reason that the mechanical processes of concentration cannot be pushed too far without causing too great a loss. Hence, a very considerable proportion of silicious gangue remains with the concentrates; so much, in fact, that in the majority of cases with which I am familiar the concentrates carry scarcely more iron than is required to flux their own silica. A familiar illustration is offered in the reverberatory practice of the Washoe smeltery at Anaconda. Apart from an occasional addition of flue dust, the reverberatory charge consists solely of roasted pyritic concentrates to which has been added, before roasting, five per cent. of limestone. The resulting slag averages about 39 per cent. silica with 43 per cent. ferrous oxide. These large reverberatories average about 295 tons (267.6 met. tons) each per 24 hours, and in spite of the high temperature and extraordinarily favorable conditions, any increase in the silica content of the slag is accompanied by a marked decrease in capacity. This illustration emphasizes two points: first, that a highly ferruginous slag of, say, 40 per cent. silica, though having a notably higher formation temperature than its more acid fellows, is more easily and cheaply smelted than they are; secondly, that average copper concentrates, with silicious gangue, must not be expected to do much more than flux their own silica. This last dictum, unless qualified, would not be correct if interpreted too positively. It applies merely to the power of the iron of the concentrates to lower the silicate degree of the slag to a reasonable standard. It does not, however, deny the enormous commercial value which this iron content may have in bringing needed iron into a general smelting mixture. For instance, a neutral ore high in lime and low in iron may be infusible by itself, producing a slag containing too little FeO to be fusible. In such a case the addition of these roasted neutral concentrates would remove the difficulty; for, although they have no

[1] I do not for a moment dispute the feasibility of making pure iron-silica slags of a far more acid composition than those just indicated. It is mainly a question of how much fuel and how much furnace capacity it is profitable to expend in so doing. As a rule, basic flux is cheaper than fuel, time, and trouble.

FeO to spare as a flux for silica, they have a great deal more of it than they need to produce a suitable slag with their own silica, providing this silica is neutralized by the earthy base of the lime ore. In other words, we release the valuable iron oxide of the roasted concentrates by substituting for it some of the CaO of our lime ore, and thus, from the total mixture, form a lime-silica slag which contains sufficient FeO to be fusible.

In the great blast-furnace plants both of Anaconda and Great Falls, much the same slag conditions obtain as with the reverberatories, excepting that the silicious charge smelted in the blast furnace demands an enormous addition of limestone. As is well known, first-class lump ore from Butte forms a considerable proportion of the charge and introduces so much silica that a great deal of lime is required to reduce the silica content of the slag to the point already indicated. The make-up of the charge varies with the ore supply and other conditions, but not long since consisted of the following materials, none of which are roasted: First-class sulphide copper ore (very silicious), 2400 lb.; pyritic concentrates (down to $\frac{3}{8}$-in. diameter), 1800 lb.; briquets, dry weight (concentrator slimes and fine raw concentrates), 2200 lb.; limestone, 3900 lb.; converter slag and cleanings, 1600 lb.; total weight of one charge, 11,900 lb.; coke required for the above charge, 1000 lb. The average sulphur content of this charge is about 11.5 per cent. Seventy-eight per cent. of the sulphur is oxidized during the smelting and the resulting matte contains 46.5 per cent. copper. The large blast furnace averages about 2500 tons per 24 hours.[1] The average analysis of the slag, representing several hundred thousand tons of charge, is SiO_2, 39 per cent.; FeO, 22; CaO, 27; Al_2O_3, 6.5; MgO, 1.5; MnO, 0.7; Cu, 0.32; S, 0.7. The limestone contains about 50 per cent. of CaO and FeO, and 5.76 per cent. silica. The coke contains 80 per cent. fixed carbon and about 16.5 per cent. ash.

The primary object of giving this condensed statement of the conditions under which the blast-furnace department at Anaconda is working, is to emphasize that, at the largest plant of its nature in the world, equipped with an elaborate research department, and guided by an unusual combination of technical and commercial skill, it is found more advantageous to use barren lime rock in the wholesale manner just indicated, than it is to allow the silica content of the slag to exceed 40 per cent.

Calculating the oxygen ratio of this Anaconda slag, we find that the oxygen in base and acid stands in the relation of about 0.8 to 1. If it

[1] One ton=907.2 kg. One pound=0.4536 kg.

were 0.75 to 1 it would be a 3 : 4 silicate; so that the average Anaconda blast-furnace slag, year in and year out, is kept a trifle more basic than even a 3 : 4 silicate and it is evident that it pays to add sufficient barren limestone to keep it down to this low degree of acidity. The consumption of coke for smelting the above mixture is 8.4 per cent. of the weight of ore and flux. The average of several tests as to the amount of air blown into these large furnaces indicates that about 60,000 cu.ft. of free air is used for each ton of charge smelted per 24 hours, or 300,000,000 cu.ft. for the 5000 tons smelted daily.

This is, of course, partial pyrite smelting with cold blast. Considerable heat is derived from the burning of the sulphides in the charge, and any decrease in the volume or pressure of the blast is followed by low-grade matte, silicious slag, cold tuyeres, and reduced tonnage. One of the most important and significant features of the Anaconda blast-furnace work remains to be mentioned: namely, the amount of material treated per 24 hours per sq.ft. of hearth area. The year's average is 6.57 tons per sq.ft. (64.1 met. tons per sq.m.), including ore, flux, and fuel. This is unusually high for reaction smelting, especially where so much of the heat is derived from the combustion of the sulphides. It is rendered possible only by keeping the silica content of the slag within the limit just indicated.

There is not space to follow up these slags as they become higher in silica and lower in base. Suffice it to say that, so long as the FeO (or MnO) forms a considerable proportion of the total basic constituents (perhaps 35 per cent, of them as a minimum) and so long as the addition of the alumina to the silica does not amount to more than 47 per cent. of the total constituents, such a slag is feasible and may be counted upon in actual work as not requiring unusual skill nor an excessive proportion of fuel. As the silica rises, these slags will, in spite of their lower formation temperatures, require more and more fuel (introducing complications where oxidation of sulphides during the smelting is desired). They will reduce the tonnage of the furnace; will tend to chill the settler; will cause more expensive smelting, and will demand much more careful supervision. Where good limestone can be obtained at any reasonable cost (from 50c. to $2 per ton in the smelter bins) it will generally be more profitable to make use of this flux to an extent sufficient to reduce the acidity of the slag to a point where there is at least two-thirds as much oxygen in the base as in the acid (a sesqui-silicate slag) or even lower. The exact limit to which this reduction of the silicate degree may be pushed to advantage with these slags comparatively high in FeO is a matter determined entirely by local conditions, and is one which demands both technical and commercial consideration of the highest order.

That our illustrations may not be confined too closely to a single district, and thus give rise to suspicion that peculiar local conditions may influence their metallurgists in the employment of these extraordinary efforts to keep their slags down to the moderate degree of acidity just indicated, I will cite one further instance. This illustration shall be that of a great custom smelter employing reverberatory furnaces exclusively and situated at a railway center where the smelting rates are notably higher on silicious than on basic ores, thus rendering it vitally important to the metallurgist to make a slag as high in silica as is possible without sacrificing furnace capacity to an extent that shall more than offset the higher smelting tariff. I refer to the late Boston & Colorado smelter at Argo, Colorado, which, under the management of Richard Pearce, was the home of advanced reverberatory smelting in the United States for many years, and where the most profitable degree of acidity of the slag was the subject of anxious and constant attention. This slag, approaching a sesqui-silicate, averaged about as follows: SiO_2, 39 per cent.; FeO, 31; Al_2O_3, 4; MnO, 5; CaO, 5; BaO, 4; MgO, 0.75; ZnO, 9; Cu, 0.45; Pb, 1; total, 99.2 per cent.

A few illustrations of operations where the slag analyses are of undoubted correctness, and where the quantities which they represent run into the hundreds of thousands of tons, are much more valuable for practical instruction than a far greater number of less thorough cases.

If the best that our most experienced and must successful metallurgists can do is to raise the silica in their slags to about 40 per cent. and, counting alumina as a base, refuse to go higher than a 3:4 silicate or, at most, a sesqui-silicate, the inexperienced practitioner may well guard against sanguine estimates as to the ease with which slags may be made running several per cent. higher in silica than these, and encroaching upon the dangerous and difficult ground which lies between the sesqui-silicate and the bi-silicate. That such slags can be made, and that they are at times commercially feasible, no one would deny for a moment; but the more practical familiarity with the subject that a man possesses the more thoroughly will he appreciate the decrease of furnace capacity, the increase of fuel consumption, and the widespread technical difficulties that keep pace with the rise in the silicate degree of his slag. Unless he allows his scientific instincts to overmaster his commercial obligations, the more assiduously will he seek means of lowering his silicate degree by the search for new sources of basic material, rather than indulge in the display of extraordinary technical ability in meeting the never-ending difficulties of his problem. If there is no escape from these unfortunate conditions, he must face the situation as it stands. There may still be a good margin of profit even with the higher smelting costs inseparable from high-silica slags, and it is to this type of furnace work that I now turn.

The slags to which most of the remainder of this article will be devoted are high in silica and earths, and low in iron. They are less common in practice than those which have hitherto occupied our attention, but are occasionally indispensable, and are coming more and more into use as the process of partial pyrite smelting gains ground.

The first illustration of this type of slag which would occur to the metallurgist is the classic slag of the Mansfeld district in Germany. The formidable appearance of a table of analyses of these slags, with their silica approaching 50 per cent., and their ferrous oxide averaging below 7 per cent., was for many years a source of astonishment and discouragement to myself, and doubtless to many other copper smelters. A brief examination of the Mansfeld smelting charge and of the slag which it yields will serve, in the light of modern experience, not to lessen our admiration for the unique and splendid process developed under the difficult conditions prevailing at Mansfeld, but to dispel all fear that it is impossible for any skilled metallurgist to make similar or even more difficult slags if circumstances demand it and if local conditions can bear the expense of high fuel ratio and decreased furnace tonnage.

The Mansfeld copper-slate, after burning in heaps (mainly to remove bitumen and water), is smelted with coke in high furnaces, and produces a slag averaging about as follows: SiO_2, 48.6 per cent.; Al_2O_3, 16.2; CaO, 17.1; MgO, 3.6; FeO and MnO, 5; K_2O and Na_2O, 5.2; ZnO, 1.8; CuO, 0.3; total, 97.8. The oxygen ratio of acid to base is nearly 1.5 : 1, or of base to acid, $\frac{2}{3}$: 1. Hence, the slag is not quite a sesqui-silicate.[1] As an illustration of how little dependent a slag of this nature is upon FeO to reduce its flowing temperature to practicable limits, I append the complete analysis of slag from the Kochhütte, Mansfeld, kindly furnished me by Mr. Anton Eilers: SiO_2, 48.56 per cent.; Al_2O_3, 17.6; CaO, 21.81; MgO, 3; FeO, 2.46; MnO, 0.32;CuO, 0.28; PbO, 0.09; ZnO, 0.85; NiO and CoO, 0.009; K_2O, 4.18; Na_2O, 0.686; S and C, 0.25; total, 99.995. This slag contains only 2.78 per cent. of iron and manganese oxides, and has an oxygen ratio of 1.44 : 1.

As it is exceedingly important to establish the fact that highly acid slags low in iron may be made in simple fusion smelting without seri-

[1] Since writing the above I have calculated the oxygen ratio of 24 analyses of late typical Mansfeld slags and found their average to be 1.41: 1, or considerably less acid than a sesqui-silicate.

ous difficulty, providing the slag is polybasic and especially where much of the silica is already present in combination with bases.[1] I will add one more illustration where neither highly trained metallurgists nor the resources of a great plant were available. In the district of Lend in the Austrian Alps lean, quartzose, pyritic gold ores were smelted into an iron matte containing 4 per cent. copper, using a small, uncooled blast furnace which handled about 10 tons of charge per 24 hours, with a consumption of 38 bushels charcoal per ton. For many years the average slag at Lend had approximately the following composition: SiO_2, 51.02 per cent.; Al_2O_3, 2.16; FeO, 19.75; CaO, 15.4; MgO, 8.57. This slag is slightly more acid than a bi-silicate and runs somewhat slowly. The fact that long experience determined it to be the most profitable slag that could be made under local conditions, and that it could be manipulated at all in the diminutive furnace, shows that the metallurgist need not fear 50-per cent. silica slags under suitable conditions and in simple fusion smelting.[2]

The next type of high-silica, low-iron slags which demands consideration bears some superficial resemblance to that of Mansfeld and Lend in its predominating earths, its high silica, and its low iron. It differs from them in several essential particulars, two of which call for especial notice. In the first place, it is commonly a product of reaction smelting instead of fusion smelting, resulting from a blast-furnace process in which oxidation plays an important role (partial pyrite smelting). Secondly, it is a type of slag which, apart from ferrous oxide, contains little base excepting CaO (occasionally also MgO). The fact that it is commonly a product of reaction smelting and confined mostly to the process of partial pyrite smelting, is an accidental rather than an essential feature. A similar slag could be made in simple fusion smelting if circumstances demanded it. It happens that the conditions under which it seems wise to attempt such a slag are the conditions which favor the employment of the partial pyrite process: namely, silicious, sparsely pyritous, dry ores, with barren limestone as the only available flux. This same set of conditions also limits the available bases mainly to ferrous oxide and lime (occasionally magnesia) together with the small percentage of alumina which is usually present.

The main profit is almost always in the silicious ores, and the aim of the metallurgist is threefold: (a) To make a slag as high in silica as is feasible, in order to smelt the greatest possible proportion of profitable

---

[1] Note that in reaction smelting where a considerable oxidation of the sulphides is desired (partial pyrite smelting) we need much free silica.

[2] The main part of the information regarding this process at Lend is taken from John A. Church's interesting and still valuable paper entitled, "Economical Results in the Treatment of Gold and Silver Ores by Fusion," *Trans.*, A. I. M. E, I, 242.

ore; (b) to make a slag as low in ferrous oxide as possible, in order to avoid the use of too much unprofitable pyritic flux ores; (c) to have the remainder of the slag consist solely of lime, this being the only available basic flux, with such little Al_2O_3 and other earths as may be present. Disregarding, for the moment, everything but the three chief constituents of the slag, silica, ferrous oxide and lime, let us examine the formation temperatures of such slags as might be thought desirable under these conditions.

FORMATION TEMPERATURE OF VARIOUS COPPER SLAGS. (*a*)

Variety of Slag.	SiO_2 %	FeO %	CaO %	Formation Temperature Deg. C.	Remarks.
3:4 Silicates	40 40 40	20 16 12	40 44 48	1190 1290 1430	Above 40 per cent. CaO the formation temperature increases rapidly and soon becomes prohibitive.
Sesqui-silicates.	42.5 43.0 43.3	21.5 17.0 12.7	36 40 44	1190 1250 1330	
Bi-silicates	48.5 49.0 49.6 50.0 50.6	27.5 23.0 18.4 14.0 9.4	24 28 32 36 40	1170 1200 1250 1330 1430	Even these very high-silica slags retain a moderate formation temperature until an excessive amount of FeO is replaced by CaO.

(*a*) From Hofman's table. Small fractions omitted.

The accompanying table agrees in at least one important particular with the results of practice: namely, that to a certain point the fusibility of slags high in lime and low in iron improves as the percentage of silica increases. This is, of course, a most favorable law for the practical smelter whose charge is overburdened with silica, and who has to depend upon limestone as his sole inexpensive fluxing material. Still, we find even the most favorable of these slags soon approaching formation temperatures which are startling to the metallurgist who is accustomed only to the slags thus far considered. The reaction smelter, dependent upon scanty raw pyrite and unlimited barren limestone as his sole basic materials, must not only contemplate the production of slags having formation temperatures up to two hundred degrees higher than his former normal limit; but he is also confronted with an obstacle which appears to be even more insurmountable than the question of fusibility. The difficulty is that in this type of smelting the prospective supply of FeO is locked up in the raw pyrite from which it can be liberated and rendered available as a slag base only by decomposing and oxidizing this pyrite in the furnace itself; in other words, by adopting a modification of pyrite smelting.

The first condition of this process is that there must be a strongly oxidizing atmosphere in the smelting zone (focus) of the blast furnace; and this oxidizing atmosphere cannot be maintained unless the proportion of carbonaceous fuel is cut down to the lowest possible limit. The slightest increase of the normal coke charge produces at least three evils, any one of which would be sufficient to ruin the process both technically and commercially. They are: (a) Increased amount and low tenor of matte, due to the Feπ, FeS which has failed of oxidation; (b) simultaneous increase in the silica content of the slag which, already at the highest possible degree of acidity, is now robbed of a portion of the only base that keeps it within the practicable limits of fusibility, and which, even when normal, contains the lowest possible proportion of this base; (c) an evil which is not so immediate and striking in its action but which is equally certain in its fatal results, i.e., the gradual creeping up of the heat in the shaft, by which the zone of high temperature becomes diffused instead of remaining concentrated at the focus. The more abundant coke and the increased volume of air required to burn it are the principal causes of this well-known condition which soon leads to complete disorganization of the smelting process.[1]

The types of slags produced in this variety of smelting are so unusual and of such high formation temperature that they are viewed with surprise, and often with suspicion, by metallurgists whose practice has not led them to replace iron with lime to an extent far beyond that customary in routine work. For this reason, I shall confine my principal illustrations to two instances where these high-silica-lime, low-iron slags were made for long periods under successful commercial conditions, and where their qualities and chemical composition are matters of common knowledge to all American copper smelters who have interested themselves in this line of work. Both description and comment must be of the briefest.

The Deadwood & Delaware smelter of South Dakota, built and managed for a period of years by Franklin R. Carpenter, operated under very peculiar conditions. The only valuable material consisted of silicious gold ores (75 per cent. silica and $20 per ton, or less, in gold) containing scarcely any sulphur. The pyritic flux was a barren silicious pyrite and pyrrhotite, replaced later by silicious pyritic concentrates from Homestake. The main basic flux was an unusually pure dolomitic

[1] As there is not space to discuss the merits of a heated blast, I may say here that it is precisely under these conditions where the heat is insufficient and yet where additional coke cannot be employed that the heated blast has its most obvious and striking application. Even a slight warming of the wind (Fulton and Knutzen say even to 60 deg. C.) is an advantage while the heating of the blast to 200 to 300 deg. C. makes a great difference in the ease and rapidity of operation. It will be noted that the requirements here are almost diametrically opposed to those in true pyrite smelting where the heating of the blast is followed by a less vigorous slagging of iron and a diminished degree of concentration.

limestone.[1] The smelting was started in 1889 with a slag which, during succeeding years, was never changed materially, and which was somewhat more acid than a sesqui-silicate, having approximately the following composition: SiO_2, 48 per cent.; FeO, 13; Al_2O_3, 5.4; CaO, 20; MgO, 13; thus having 1.57 O on the acid side to 1 O on the base side. The acidity was often increased to 1.75:1, and even higher. The slag was always well melted and flowed perfectly, although inclined to chill rapidly. It had a peculiarly low metal content and the ratio of concentration was extraordinary, sometimes reaching 50:1 and more. Several years later Mr. Lloyd, who had had charge of the furnaces for two years, said: "Our slag is a complex silicate which is normally about half way between sesqui-silicate and bi-silicate. A typical analysis should show: SiO_2, 48.5 per cent.; FeO, 16; MgO, 12; Al_2O_3, 3.5; RO bases to balance, 2. On this slag we have made our best runs. It is a peculiarly pretty slag of glassy lustre when chilled suddenly, but of a stony grayish-brown appearance when chilled slowly. In case of the FeO becoming low, the proper course is to increase the silica. In this connection we have made slags assaying 53.8 per cent. silica with good results, but have never been able to make any slag which will drive as fast as the type given above. At about 44 per cent. silica the alumina appears to become an acid, and makes a very bad slag. The type given is quite fluid, does not chill readily, and can be drawn into a very fine thread. By observing the thickness of these threads one can form a very close idea of the FeO contents of the slag."

Later A. H. Carpenter, after ten months' experience with the furnaces, found that he could do the best and most rapid work on a slag approximating; SiO_2, 51.4 per cent.; FeO, 12.2; CaO and MgO, about 30; and probably Al_2O_3, 3.5, and RO bases, 2. With this slag he was smelting some 200 tons of charge, about one-half of it being limestone, in a furnace having a hearth area of 36x144 in., which is equivalent to 5.55 tons of charge per sq.ft. of hearth area (54.17 met. tons per sq.m.). This is rapid smelting for this kind of work, although it must be noted that about one-quarter of the entire weight of the charge is made up of the CO_2 of the limestone.

Dr. Carpenter informed me that it required about 12 to 14 per cent. of the weight of the entire charge in good coke, or 18 per cent. of poorer coke, to keep the furnace in good condition. The slag produced at this plant was a most unusual type for regular commercial smelting, and must have had a high formation temperature, perhaps approximating

[1] A detailed description of this instructive work may be found in a paper entitled, "Pyritic Smelting in the Black Hills," by Franklin R. Carpenter, *Trans.*, A. I. M. E., XXX, 764. Much of the information given in this essay, however, is derived from late personal communications from Doctor Carpenter in regard to later work done at the D. & D. smelter, and from statements by R. L. Lloyd and Arthur Howe Carpenter who had charge, at separate periods, of the blast-furnace department.

1350 deg. C. As it flowed freely, and with ample heat to spare, it is probable that it attained a temperature of at least 1450 deg. C. before leaving the furnace.

Metallurgists were inclined to believe that, in an ordinary copper furnace with moderate fuel consumption, the ability to produce a slag so low in iron and so high in alkaline earths was due largely to the fact that fully one-third of these earths consisted of magnesia, thus multiplying the number of bases in the slag, and presumably increasing its fusibility.[1] That this opinion was erroneous is shown by the later work (1901-1908) carried on at Rapid City, South Dakota, by Messrs. Fulton and Knutzen on ores quite similar to those described in the preceding illustration, but with the use of pure limestone, instead of highly magnesian limestone, as the chief basic flux.[2] I regret that lack of space permits me to give only the bare facts of this interesting work. Mr. Fulton has furnished me daily slag analyses for two months, during which time the average composition was about as follows: SiO_2, 48.5 per cent.; FeO, 11.6; CaO, 33; Al_2O_3, 5.5; total, 98.6. After running 10 or 12 days on a slag of this composition, the furnace would begin to show signs of distress, the smelting zone would creep higher in the shaft, the tuyeres would grow dark, and the tonnage would diminish. An addition of pyrite flux sufficient to raise the iron content of the slag several per cent. would then be made. After two or three days of this restorative treatment the furnace would resume its proper condition, and would again be ready for its normal charge.

The furnace used was of the ordinary rectangular, slightly boshed, water jacketed type, having a cross-section at the tuyeres of 48x144 in. (4.46 sq.m.) and a hight from tuyeres to off-take of only 9.5 ft. (2.9 m.). Owing to the shallow ore column, it was impossible to employ a blast pressure of more than 14 to 18 oz. per sq.in. The average amount of charge smelted per 24 hours was 2.7 tons per sq.ft. of hearth area (26.35 met. tons per sq.m.). The blast was heated very slightly, seldom exceeding 80 deg. C. The desulphurization in this furnace averaged about 71.2 per cent. Some 16 per cent. of inferior coke was used, averaging 72 per cent. fixed carbon and 24 per cent. ash.

Here is a slag made year after year under strictly commercial conditions, with over 48 per cent. SiO_2 and only 12 per cent. FeO. Apart from a small amount of Al_2O_3, the only base is CaO, which averages

[1] All experiments with which I am acquainted indicate that the replacement of lime by magnesia causes a moderate rise in the formation temperature until about three-fourths of the lime has been replaced, beyond which limit the temperature rises with great rapidity.

[2] This work is described in detail in a paper entitled, "Sulphide Smelting at the National Smelter of the Horseshoe Mining Company, Rapid City, South Dakota," by Charles H. Fulton and Theodore Knutzen, *Trans.*, A. I. M. E., XXXV 326. Much of the information that appears in the present essay pertaining to this practice is from late personal communications from Mr. Charles H. Fulton, president of the South Dakota State School of Mines.

over 32 per cent. At times, the slag analyses for 48 hours or more drop to 9.7 per cent. FeO, with 49.5 SiO_2, and 33.5 CaO; and this result is attained in a low furnace, with poor coke, and with a blast only slightly warmed. It is evident that our ordinary ideas of feasible slags must be modified materially.[1]

I regret that it is impossible for me, in this article, to discuss more fully the influence upon slags of alumina, baryta, and zinc oxide.

Recapitulation.—The ordinary slag resulting from the mere fusion of roasted ores, or ores which require no roasting and whose earthy constituents already exist largely in combination with silica, is too familiar to demand extended comment. For the most part, it is notably a fusible slag, yet one whose flowing qualities are not in harmony with its formation temperature. That is to say, although its formation temperature becomes lower as its acidity increases, yet its flowing qualities diminish materially after the silica reaches 40 per cent. Above this point it would be necessary to increase both coke and blast to a considerable extent in order to make the slag hot enough and liquid enough for the fast driving of the furnace now demanded. Apart from the direct expense entailed, other well-known complications would arise from this increase, such as diminished oxidation, increased fall of matte, necessity for a higher ore column, etc. It is, therefore, the practice at nearly all large smelters, to add sufficient basic flux, usually barren limestone, to keep the silica content of the slag down to a maximum of 40 per cent.; and this is true both for blast and reverberatory furnaces. As the charge is somewhat acid to start with, it follows that the 40 per cent. silica slag will contain a considerable proportion of lime, often as much as 27 per cent. Such a slag melts rapidly, flows freely, keeps the settler open, and is low in valuable metals. With suitable settling facilities and with the production of a tolerably high-grade matte (perhaps 40 to 48 per cent. copper), the blast-furnace slag should not contain over 0.7 per cent. of the assay of the matte in copper.[2]

A suitable polybasic slag may contain as much as 50 per cent. silica and as little as eight per cent. FeO, and still be reasonably fusible and flowable, providing it does not become more acid than a sesqui-silicate (two-thirds as much oxygen in the base as in the silica). Both its formation temperature and its flowing temperature depend much upon the number and proportion of its bases, as well as upon the proportion of silica already in combination with the earth.[3] The smelting conditions

[1] C. A. Heberlein contributes an instructive account of the successful production of high silica-lime slags at the Magistral smelter, Zacatecas, Mexico, *Eng. and Min. Journ.*, LXXXVIII, 107,177.

[2] On this basis, if the blast-furnace matte assayed 46 per cent. copper, the slag should not contain more than 46 x 0.007 or 0.322 per cent. copper.

[3] It will be noticed that in fusion smelting we prefer combined silica, while in reaction smelting we must have at least a certain amount of free silica.

approach those of the iron-ore blast furnace, and heated wind is advantageous.

A slag containing as much as 48 per cent. silica, 6 per cent. alumina, and with ferrous oxide as low as 10 per cent., is entirely feasible, even though its sole remaining base consists of lime. While requiring much more coke than the easy-smelting, ferruginous slags, still it may be made with a fuel consumption of one to six. It must be noted, however, that in the rather low furnaces in which such slag has thus far been produced, it has been found necessary to add a litle excess iron, periodically, in order to keep the tuyeres hot, and to prevent the smelting zone from creeping up the shaft. So far as I am aware, such slags up to this time have been made solely in partial pyrite smelting, so they have had the aid of the heat furnished by the oxidation of the sulphides in the charge. On the other hand, this proportion of sulphides has always been low; never exceeding 16 per cent. of the entire charge and often being much below this figure. While such slags are entirely feasible as a commercial proposition, they are difficult to manage, and demand great care and skill. Consequently, they are only in place when imperatively demanded by local conditions. When such is the case, they need not be feared and may, at times, prove the salvation of an enterprise. They are not well suited to our present system of reverberatory smelting as, apart from various serious drawbacks, they demand such a high temperature that only the best of fuel will give a reasonable tonnage, while the arch and flue of the furnace require frequent repairs.

From an examination of the results of other metallurgists, as well as from my own limited personal experience with slags of this nature, I agree in the main with Mr. Fulton's summary of the situation as expressed in a recent personal letter, and condensed to suit the requirements of this article. He believes that in smelting ores low in sulphides, the main essentials for success in making these slags so high in silica and lime, and so low in iron are: (1) Ample coke of good physical and thermal quality, which should persist down to the tuyeres, and should approximate 14 per cent. of the weight of ores and fluxes. (2) Moderate blast; else the heat creeps up, and the tuyeres chill. This means also moderate tonnage, seldom exceeding four tons per sq.ft. of hearth area per 24 hours (39 met. tons per sq.m.). (3) Extreme care in charging, and in maintaining a regular hight of ore column with proper distribution of the charge, and avoidance of unduly large pieces of ore or limestone. (4) Periodical lowering of the silica and lime content of the slag by aditional iron whenever the furnace shows signs of distress; i.e., creeping-up of the smelting zone and serious crusting of the tuyeres.

There is no doubt, I think, that the preheating of the blast aids this process materially, and it is probable that a high smelting column, perhaps 12 to 16 ft., would be of great advantage after the technical details of the operation had adapted themselves to the new conditions involved.

In conclusion, I will offer a single suggestion of a practical nature. Whenever the production of any variety of difficult slag is contemplated it is well to lead up to it gradually, beginning with the normal type, and increasing the difficulties as the furnace men gain experience and confidence. I have often found that a type of slag which threatened disaster, if approached suddenly, could be managed with ease after the men had become accustomed to its peculiarities. There is much that is psychological in the running of difficult ores. If the furnace foreman feels certain that they are impossible to smelt, the result is very likely to prove the correctness of his views. On the other hand, when he has gradually worked himself and his men up to this new standard, he takes the greatest pride in being able to accomplish such unusual results, and feels that scarcely any mixture is too difficult for him and his highly trained crew; and again his views are correct.

NOTE.—I desire especially to acknowledge the aid of Messrs. Anton Eilers, F. R. Carpenter, C. H. Fulton, C. A. Heberlein, S. E. Bretherton, William Wraith, C. D. Demond, M. W. Krejci and F. Laist. E. D. P.

COPPERAS.

The production of copperas (sulphate of iron) in the United States in 1909 was larger than in any previous year, amounting to 42,225 short tons valued at $464,475. The principal supply was derived from iron and steel, sheet and wire plants, where copperas is obtained as a by-product in cleaning plate and wire in a sulphuric acid bath preparatory to galvanizing or tinning. As in former years, the United States Steel Corporation supplied the bulk of the output. The other principal producers were the Pennsylvania Salt Manufacturing Company, Philadelphia, Penn., the Stauffer Chemical Company, San Francisco, Cal., S. P. Wetherill Company, Philadelphia, Penn., Wickwire Brothers, Cortlandt, N. Y., and the E. I. du Pont de Nemours Powder Company, Wilmington, Del. The last-named company recovers copperas as a byproduct in the manufacture of dynamite, etc.

PRODUCTION OF COPPERAS IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Short Tons.	Value.	Year.	Short Tons.	Value.	Year.	Short Tons.	Value.
1895	14,118	$69,846	1900	12,374	96,517	1905	21,103	147,721
1896	11,170	52,662	1901	23,586	112,336	1906	22,839	228,390
1897	11,924	56,565	1902	19,784	118,474	1907	26,771	294,481
1898	11,285	58,105	1903	20,240	121,440	1908	35,334	388,674
1899	13,770	108,508	1904	16,956	118,692	1909	42,225	464,475

A considerable portion of the copperas produced by the chemical manufacturers is converted at once by roasting into Ventian red for paint makers. The above table does not include this production of copperas as an intermediate product.

Prices.—Prices were practically unchanged throughout 1909. New York quotations were 55c. per 100 lb. for copperas in bulk, 65@75c. per 100 lb. in barrels, and 60@70c. per 100 lb. in bags.

CORUNDUM AND EMERY.

The domestic production of corundum and emery has never constituted more than about one-fifth of the total consumption. The reason for this is the cheaper supply available from Greece. Workable deposits of corundum are not uncommon in the United States, but, as a rule, they are so situated as not to compete with the imported material.

The following table gives statistics of the production and imports of corundum and emery in the United States for a series of years. The increase of 440 tons in the production of 1909, as compared with that of 1908, was equally divided between the States of New York and Pennsylvania. No production was reported from the corundum mines of Montana and North Carolina.

STATISTICS OF CORUNDUM AND EMERY IN THE UNITED STATES.

Year.	Production. (a)		Imports.				
			Grains.		Ore and Rock.		Other Mfrs.
	Short Tons.	Value. (b)	Pounds.	Value.	Long Tons.	Value.	Value.
1897	2,193	$111,810	520,095	$20,022	5,209	$107,644	$2,211
1898	3,742	207,430	577,655	23,320	5,547	106,269	3,810
1899	3,970	228,570	728,229	29,124	7 435	116,493	11,514
1900	5,030	247,100	661,482	26,520	11,392	202,980	10,006
1901	4,305	146,040	1,086,729	43,217	12,441	240,856	10,926
1902	4,251	104,605	1,665,737	49,107	7,157	151,959	13,776
1903	2,542	64,102	3,595,239	109,272	10.884	194,468	17,829
1904	1,932	57,235	2,281,193	109,772	7,054	138,931	11,721
1905	(c)2,315	19,677	3,209,914	143,729	11,072	185,689	17 996
1906	(c)2,147	22,780	4,655,168	215,357	13,840	286,386	19,105
1907	(c)1,069	12.294	4,282,228	186,156	11,235	211,184	15,282
1908	790	10,360	1,845,366	89,702	8,084	146,105	12,592
1909	1,230	16,510	1,890,010	88,782	10,168	226,494	19,800

(a) Statistics of the United States Geological Survey for 1901-1903. (b) Values have not much significance owing to the wide variation in the quality of the materials combined in the totals. (c) Emery only.

The principal consumers of corundum and emery in the United States, some of whom own the mines from which their raw material is secured, are the following:

Abrasive Mining and Milling Company, Plymouth, Ind.
Ashland Emery Mills, Chester, Mass.
Best, L. & Co., New York City.
Diamond Mills Emery Co., Easton, Penn.
Hampden Emery Mills, Hampden, Mass.
Jackson Emery Mills Co., Easton, Penn.
Pittsburg Emery Wheel Co., Pittsburg, Penn.
Sterling Emery Wheel Mfg. Co., New York City.
Walpole Emery Mills, Walpole, Mass.

The corundum production of Canada comes exclusively from the Province of Ontario, and, principally, from the Craigmont district. The Canada Corundum Company suspended its operations at Craigmont in 1908. Early in 1909, operations were resumed by the Manufacturers Corundum Company, which secured a lease from the Canada Corundum Company. The old system of open-cut mining is still in use. The concentrating mill is run only on the day shift. The company employs 135 men at the mine and mill.

The total amount of corundum ore treated in Canada during 1909 amounted to 35,894 tons, from which was produced 1579 tons of grain corundum. The total shipments amounted to 1491 tons, valued at $157,-398, or an average of a little over 5c. per lb. The Canadian production of corundum for a period of years is compared in the following table:

THE CORUNDUM INDUSTRY OF CANADA.

	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Production, tons...	534	1,137	1,119	1,665	1,644	2,274	1,892	1,089	1,491
Value.............	$53,115	$83,871	$87,600	$150,645	$149,153	$204,973	$177,922	$100,398	$157,398
Number of men....	68	95	186	202	....	....	....	....	......
Wages paid........	$30,406	$34,674	$106,332	$139,548	....	....	....	....	......

The Grecian emery, which holds such a high reputation, comes mainly from the island of Naxos; it is exported through the port of Syra, where it brings about $20 per ton. The total exports of emery ore from Greece in 1909 amounted to 7964 metric tons, as compared with 7954 metric tons in 1908. The average value of the exported ore in 1909 was $20.70 per metric ton.

It may be noted here that the Payne tariff act of 1910 removed the duty, which, under the Dingley tariff, amounted to 1c. per lb. on grain emery and 25 per cent. *ad valorem* on manufactures of emery, putting both emery grains and manufacturers of emery on the free list.

CRYOLITE.

No commercial deposits of cryolite are known to exist in the United States, and the domestic market is supplied entirely by importations from the mines at Ivigtut, South Greenland. The consumption of the mineral is chiefly in the chemical industry, where it is used in the manufacture of sodium salts, special porcelains and glasses, etc. The Pennsylvania Salt Manufacturing Company, of Natrona, Penn., is the principal consumer. The amount and value of the imports into the United States during recent years are given in the following table:

IMPORTS OF CRYOLITE IN THE UNITED STATES.

Year.	Long Tons.	Value.	Av. per Ton.	Year.	Long Tons.	Value.	Av. per Ton.
1900	5,437	$ 72,763	$13.37	1905	1,600	$22,482	$14.05
1901	5,383	70,886	13.17	1906	1,505	29,683	19.72
1902	6,188	85,650	13.84	1907	1,284	28,902	22.51
1903	7,708	102,879	13 35	1908	1,124	16,445	14.63
1904	959	13,708	14.30	1909	1,278	18,427	14.42

(*a*) Includes imports of artificial cryolite or cryolith.

The use of fused cryolite as the electrolyte in the manufacture of aluminum has been entirely supplanted by the employment of artificial cryolite. This is made by roasting fluorspar with potassium sulphate and charcoal, lixiviating with water and treating the solution containing potassium fluoride with sodium and aluminum sulphates.[1]

A description of the cryolite deposit and method of mining at Ivigtut, Greenland, is given in Vols. I and III of The Mineral Industry. In Vol. II the methods of treating the mineral as practised in the United States and Denmark are discussed, and the equipment of the Pennsylvania Salt Manufacturing Company is described.

[1] Ger. pat. No. 205,209, Nov. 20, 1907.

FELDSPAR.

By Frederick W. Horton.

Conditions in the feldspar industry in the United States during 1909 were very unsatisfactory and showed but slight improvement over those in 1908. The principal producing States, in the order of their importance, were Maine, Pennsylvania, Connecticut, New York and Maryland. For the first time a considerable output was reported from Vermont. Statistics of production during recent years are given in the accompanying table:

FELDSPAR IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

Year	Crude.		Ground.		Total.	
	Quantity.	Value	Quantity.	Value.	Quantity.	Value.
1901	9,960	$21,699	24,781	$198,753	34,741	$220,422
1902	21,870	55,501	23,417	194,923	45,287	250,424
1903	13,432	51,036	28,459	205,697	41,891	256,733
1904	19,413	66,714	25,775	199,612	45,188	266,326
1905	14,517	57,976	20,902	168,181	35,419	226,157
1906	39,976	132,643	32,680	268,888	72.656	401,531
1907	31,080	101,816	53,469	397,253	84,549	499,069
1908	18,840	65,780	48,400	335,138	67,240	400,918
1909	(b)	(b)	(b)	(b)	73,090	398,340

(a) Statistics reported by the U. S. Geological Survey, except for 1909. (b) Not separately enumerated.

Grades and Prices.—Potash feldspar is usually graded into three classes, according to its freedom from iron-bearing minerals, quartz and muscovite. No. 1 potash spar usually contains less than 5 per cent. quartz, but little muscovite and is free from biotite, tourmaline, garnet, etc. No. 2, or "Standard," contains from 15 to 20 per cent. quartz, but is largely free from muscovite and iron-bearing minerals. No. 3 contains higher percentages of quartz and other undesirable minerals. The soda feldspars are graded in a similar way, but as they are free from quartz the classification is dependent upon the quantity of iron-bearing minerals (principally hornblende) which they contain. Crushed feldspar, used for abrasive purposes and poultry grit, is graded according to size.

The price of feldspar f.o.b. at the mills varies considerably according to locality. Crude No. 2 or Standard feldspar, in Maine, sold for \$2.50@3 per ton; in southern New York and Connecticut for \$3.50@4;

in Pennsylvania for \$3.75@4.50; in Maryland for \$3.50@4, and in Trenton, N. J., for \$5@5.25. Crude No. 1 is worth from 50c. to \$1.50 per ton more than Standard, and crude No. 3 brings less by about the same amount. Grinding to ordinary sizes adds from \$3 to \$4.50 per ton to the price of the crude product. The best potash feldspar used in the manufacture of artificial teeth sold from \$6@8 per bbl. of 350 lb. General market conditions during 1909 was unsatisfactory.

Feldspar Mining in the United States.

Connecticut.—The principal miners of feldspar in Connecticut during 1909 were the Eureka Mining and Operating Company, L. W. Howe, John C. Wiarda & Co., the Bon Ami Company, and H. G. Andrews. The first-named company worked two quarries in Middlesex county, one, one-half mile southeast of Middle Haddam, and the other two and one-half miles northwest of Portland. The feldspar is hauled by teams to the Connecticut river and shipped in barges to Trenton, N. J., where it is milled by the Eureka Flint & Spar Company. The Howe quarry, near South Glastonbury, is the largest feldspar quarry in the State and has been worked for over 40 years. The spar is hauled by wagon to the Howe mill at South Glastonbury. This plant has a capacity of about 50 tons per 24 hours, and is equipped with two chaser mills and five tube mills. John C. Wiarda & Co. also operates a mill in South Glastonbury, treating the feldspar from its quarry south of the town. This mill has a capacity of about 30 tons per 24 hours and is equipped with one chaser mill and three small-sized tube mills. Most of the output of this company is used in the manufacture of glass and enamel ware. The Bon Ami Company operated a quarry at South Glastonbury milling the spar at its plant at Manchester. The feldspar from the Andrews quarry, which is about 2½ miles south of South Glastonbury, is marketed crude. The Consolidated Feldspar Company has a quarry and mill at White Rocks, near Middletown, but it is understood that this company was inactive during 1909. The feldspar from the Connecticut deposits is a white to cream-colored microcline, or orthoclase, intergrown with minor amounts of albite. No. 2, or Standard is practically the only grade shipped.

Maine.—The principal producers of feldspar in Maine during 1909 were the Golding Sons' Company, with quarries at Georgetown, the Trenton Flint & Spar Company and the Maine Feldspar Company, the last two operating deposits a few miles northwest of Cathance. The product from the quarry of Golding Sons' Company is milled at Trenton, N. J., to which point it is shipped by vessels from the Kennebec river. At the quarries of the Maine Feldspar Company the rock is hauled by teams to Cathance station and shipped by rail to the company's mill at Littlefield. The Trenton Flint & Spar Company operates a mill on the Cathance river, about one-half mile north of Cathance station. The plant has a capacity of about 16 tons in 24 hours, the equipment consisting of three chaser mills and four ball mills. The crude feldspar is hauled to the mill in wagons, and the ground product shipped via the Maine Central railroad. The feldspar mined at all the Maine quarries is very similar in character and consists of a buff-colored orthoclase or microcline, associated with small quantities of albite. Most of the Maine feldspar is classed as No. 2 or Standard, but by careful hand picking a small amount of No. 1 rock is obtained.

Maryland.—Feldspar is mined in Cecil, Howard, and Baltimore counties. The deposits of Cecil county are of the soda-pegmatite variety, and are similar to those of southern Chester county, Pennsylvania. In Howard and Baltimore counties the quarries are of the usual granite-pegmatite type, with the exception of the Frost quarry at Davis, where the rock is intermediate in composition between a soda and granite pegmatite. The principal operators of feldspar deposits in Maryland in 1909 were the Eureka Mining and Operating Company, Parlet & Cavey, Guilford & Waltersville Granite Company, Golding Sons' Company, and the Deland Mining and Milling Company. The greater part of the feldspar mined in the State was ground in Trenton, N. J., and Wilmington, Delaware.

Minnesota.—In Lake county a considerable quantity of plagioclase was mined. This material was ground by two firms in Duluth, and was used mainly for abrasive purposes.

New York. (By D. H. Newland.)—There were no new features of importance in the feldspar business during 1909. The market for pottery grades showed little improvement over the depressed conditions of the preceding year and consequently gave no encouragement to the extension of operations by the active quarries or to the opening of additional deposits. The production of feldspar for roofing purposes occupied a prominent place in the industry, but the output of the present quarries will be equal to the demands for that material for some time to come. The Crown Point Spar Company, of Crown Point, and the Barrett Manufacturing Company, with quarries near Ticonderoga were producers of roofing spar which is really a crushed pegmatite containing more or less quartz, mica and the usual accessory minerals in addition to feldspar. The former company also made a small output of pottery feldspar and scrap mica which were obtained as by-products in the milling operations.

The main part of the supply of pottery feldspar came from the quarries of P. H. Kinkel's Sons, near Bedford, Westchester county. The property of the Claspka Mining Co., at Batchellerville, Saratoga county, was taken over and operated by the Adirondack Spar Company, of Glens Falls. The total production of feldspar in New York in 1909 was 13,871 short tons valued at $46,444.

Pennsylvania.—The principal feldspar quarries of Pennsylvania are in Chester and Delaware counties. With the exception of the deposits in the extreme southwestern part of Chester county, where the principal mineral is albite or soda feldspar, the occurrences are of the usual type of granite pegmatite. In 1909 but two companies operated quarries producing only soda feldspar. These were the Sparvetta Mining Company, with a quarry one-half miles west of Sylmar station, Maryland, and the Brandywine Summit Kaolin & Feldspar Company, working a deposit one-half mile north of the Sparvetta quarry. In these soda pegmatites quartz is entirely absent, and the principal iron-bearing mineral is hornblende. At the mill of the Sparvetta company the feldspar is heated in a continuous-feed kiln, and while hot is sprayed with cold water. This shatters the rock and enables it to be ground more easily. The grinding department is equipped with three chaser mills and three tube mills and has a capacity of about 50 tons per 24 hours. A considerable part of the product from the neighboring quarries of the Brandywine Summit Kaolin & Feldspar Company is ground at this mill. Another quarry of the Brandywine Summit Kaolin & Feldspar Company is situated at Chatham. Here the feldspar is a pinkish-gray microline. The rock is shipped by rail to the mill of the company at Brandywine Summit, Delaware county. The Pennsylvania Feldspar Company, of Philadelphia, operated a quarry and mill at Toughkenamon. The grinding plant has a capacity of about 20 tons per 24 hours, the equipment consisting of a Blake crusher, chaser mill and four small tube mills. In Delaware county feldspar was mined in only one locality, namely, at Elam, where the Brandywine Summit Kaolin & Feldspar Company operated a quarry yielding potash spar.

Vermont.—In 1909 a feldspar quarry was opened at Chester Depot, Windsor county, by A. L. Stone. A considerable quantity of mineral was marketed and the owner contemplates the erection of a mill.

Virginia.—At the Pinchback mica mines near Amelia Courthouse considerable feldspar was saved as a by-product and shipped to Trenton, N. J. The Bedford Spar Company, which opened a quarry at Lowry in 1908, continued to operate on a small scale.

Feldspar Mining in Canada.

The Canadian production of feldspar in 1909 was 10,286 tons valued at $35,694. The major portion of the output was derived from the townships of Laughborough, Bedford and Portland, in Frontenac county, Ontario. The feldspar occurs in pegmatite as orthoclase or perthite, the latter consisting of interlaminated orthoclase and albite. The usual impurities are quartz, mica, hornblende, tourmaline and pyrite. The serious difficulty in mining feldspar deposits in this section is the cost of transportation to shipping points on the railway. This item alone ranges from 45 to 80c. per ton. The impure material is cobbed but on account of the low price of the product and the relatively high cost of mining and transportation, spar which needs constant cobbing cannot be mined at a profit. The cost of mining is from $1.10 per ton, loaded on the cars at the most favorably situated mines to as high as $2.75 per ton at smaller mines less favorably situated. Practically all of the feldspar from this region is used in the pottery industry. In Quebec, a quantity of high-grade "dental spar" valued at from $16@20 per ton at Buckingham, was shipped from the Villeneuve mine.

Methods of Mining and Milling.

Feldspar mining is carried on almost entirely by open-cut methods. However, in a few quarries in Pennsylvania and Ontario where the pegmatite is overlain by a considerable thickness of worthless material, the deposits are developed by short tunnels. In the New England States and New York the pegmatite is usually firm and undecomposed even at the surface and it is necessary to drill and blast most of the material, but in Pennsylvania and Maryland most of the pegmatite is much decayed at the surface, the region being unglaciated, and can be mined with pick and shovel. In most of the quarries where the rock is hard, steam drills are used, but drilling by hand is done at some of the smaller properties. The blasted rock is broken with sledges to pieces 6 in. or less in size and if the feldspar is to be used for making pottery the material is cobbed and hand picked to remove quartz, mica and iron-bearing minerals. Where the pegmatite has been weathered, as in Pennsylvania and Maryland, screening and washing may be necessary to free the feldspar from dirt. At quarries producing spar for the pottery trade the cost of mining is from $2 to $2.50 per ton, but when pegmatite is mined for roofing purposes or poultry grit, cobbing and hand sorting are unnecessary, and the cost of mining may be as low as 50c. per ton.

The methods of grinding feldspar are extremely simple. The spar as received is generally fed directly to a chaser mill in which it is ground to pass a 20-mesh screen. The chaser mill is similar in construction to the Chilean mill, but in place of steel rollers and pan, the wheels and bottom of the mill are of buhrstone. In a few cases the spar is crushed in a jaw breaker before going to the chaser mill. Crushed material from the chasers is screened, the oversize being returned to the chaser mill and the undersize going to tube mills. The ordinary type of tube mill is a steel cylinder 6 to 7 ft. long and of slightly greater diameter. The mill revolves on a horizontal axis, is lined with an artificial silica brick or silex and is charged with two to four tons of Norwegian or French flint pebbles, two to three inches in diameter. The tube mills grind from two to six tons of spar at a charge according to size. Feldspar for pottery purposes is ground from four to six hours, at the end of which time over 95 per cent. of the material will pass through a 200-mesh screen. When the spar is used in making glass or enamel ware, it is ground for only two or three hours and about 75 per cent. of the product will pass a 200-mesh screen. In grinding feldspar for poultry grit or roofing purposes, the spar is first crushed in the jaw or rotary breakers and then between rolls, after which the product is sized on vibrating screens. A detailed description of the preparation of feldspar for market at the mill of the Golding Sons' Company at Trenton, N. J., is given in Vol. XVII of The Mineral Industry. The methods employed at this plant are typical of milling practice in this country.

FLUORSPAR.

By F. Julius Fohs.[1]

In 1909 the production of fluorspar in the United States was confined to Colorado, Illinois, Kentucky, and New Mexico, the last-named State being a producer for the first time. An inspection of the accompanying tables shows that the sale of domestic fluorspar far exceeded that of any previous year. There were 45,801 tons of fluorspar mined and 50,843 tons valued at $301,704 marketed. The quantity mined was 876 tons less than in 1908, and the stock at the close of the year was also less. Sales exceeded those of 1908 by 12,048 tons, the increase in value being $76,706. The tonnage marketed in the five years previous to 1909 was between 36,000 and 39,000 tons annually. The material increase in the quantity sold in 1909 is accounted for by the resumption of normal business conditions, the placing of a tariff on imported fluorspar in August, 1909, and an increase in the use of the mineral. The falling off in the sale of lump fluorspar shown by the table is partly due to the listing of some lump as gravel spar and partly to a decreasing demand for lump. The decrease in tonnage mined was due to curtailment of output by Kentucky producers forced on them by their inability

TABLE I. FLUORSPAR STATISTICS FOR 1908 AND 1909. (a)
(In short tons.)

District.		Marketed.					Stock. Dec. 31.
	Mined.	Gravel.	Lump.	Ground.	Total.	Value.	
1908 (b)							
Colorado and Arizona (c)	745	745	....	....	745	$4,518	....
Illinois (c)	33,912	21,332	6,189	4,206	31,727	172,838	3,965
Kentucky	12,010	2,840	307	3,176	6,323	48,642	12,899
Total	46,677	24,917	6,496	7,382	38,795	$225,998	16,864
1909.							
Colorado and New Mexico	1,700	650	850	....	1 500	$8,840	200
Illinois	39,762	31,020	2,188	8,335	41,543	239,631	920
Kentucky	4,339	4,835	336	2,629	7,800	53,233	10,116
Total	45,801	36,505	3,374	10,964	50,843	$103,704	11,236

(a) Statistics collected by F. J. Fohs. (b) The statistics for 1908 differ slightly from those collected independently by *The Mineral Industry* which reported a production of 39,389 tons for that year. (c) Statistics of U. S. Geological Survey.

[1] Prepared with permission of the Director, Kentucky Geological Survey.

to meet cut prices. As compared with Illinois producers they are at a disadvantage owing to a difference in cost between land and river haul, and in freight rates, the latter alone amounting to 20 to 60c. per ton on crude and 40 to 80c. per ton on ground fluorspar. The year 1910 opened with better prospects for Kentucky shippers to Northern and Eastern points. The tonnage in Colorado continued small owing to low grade of product and lack of proper cleaning facilities. The sale of Arizona fluorspar is limited, due to absence of transportation and distance from markets. The New Mexico deposits have a brighter outlook than those of Arizona, for the markets are more accessible. The installation of new Foust jigs at Illinois plants is expected to increase their output, but whether these jigs have proved a success has not been learned.

TABLE II. PRODUCTION OF FLUORSPAR IN THE UNITED STATES.
(In short tons.)

Year.	Mined.	Value.	Per Ton.	Year.	Mined.	Marketed.	Value.	Per Ton.
1900	21,656	$113,430	$5.24	(b) 1905	38,918	36,162	$228,543	$6.32
1901 (a)	19,586	113,803	5.81	(b) 1906	31,592	37,034	211,231	5.70
1902 (a)	48,018	271,832	5.19	(b) 1907	39,777	38,922	223,308	5.76
1903 (a)	42,523	213,617	4.28	(b) 1908	46,677	38,795	225,998	5.83
1904 (a)	36,452	234,755	6.44	(b) 1909	45,801	50,843	301,704	5.94

(a) Statistics of U. S. Geological Survey. (b) Statistics collected by F. J. Fohs. The figures for 1905 to 1908 inclusive differ slightly from those obtained independently and reported by *The Mineral Industry* for these years. See table following.

The number of firms active in mining and marketing fluorspar in 1909 was as follows: New Mexico, 1; Colorado, 3; Kentucky, 7; and Illinois, 5. The principal shippers were: Albany Mining and Investment Company, Kentucky Fluorspar Company, and the Roberts Fluorspar Company, in Kentucky; and Fairview Fluorspar and Lead Company, Rogers Brown & Co. (Rosiclare mines), and the Roberts Fluorspar Company, in Illinois.

Prices.—The range in prices for 1909 was as follows: Unwashed gravel, $4.50@5.00; washed gravel, $4.75@7.00; No. 2 lump, $5.50@7.00; ground, in bulk, as low as $8; No. 1 and No. 2 ground, $10@11; barrelled extra No. 1, $11.40@12.50. The average prices of domestic fluorspar for 1909 were: Gravel, $4.74; lump, $5.94; ground, $9.99, and the average for all grades, $5.94. Fluorspar, usually barrelled, retailed in quantities of from 50 lb. to ton lots, as follows: Crude, $10@20, and ground, $20@32 per ton. Crude foreign fluorspar was quoted at $8.50 per long ton ex-dock. New Mexico lump fluorspar sold at $5.25 per ton.

According to Burchard, the price of fluorspar in Colorado varies, depending upon its content in calcium fluoride and silica. For material (hand-cobbed gravel spar) containing 80 per cent. calcium fluoride and not exceeding 15 per cent. silica the price is $5 per ton. For each additional per cent. of calcium fluoride an additional 20c. is paid, so that fluorspars containing 85 and 90 per cent. calcium fluoride bring $6 and $7 per ton respectively.

Effect of the Tariff.—The imposition of a $3 tariff on fluorspar has resulted in broadening the market without permitting an increase in prices. The latter are still regulated by foreign importations, but only at Atlantic coast ports and not at Pittsburg, as was formerly the case. From data secured from an entirely competent and trustworthy source the cost of gravel fluorspar imported into this country from the English waste dumps of Derbyshire lead mines is $1.95 to $2.31 per short ton laid down at Partington or Liverpool. The ocean freight rate is $1.09 to Atlantic ports such as Philadelphia or Baltimore. The freight rate from Baltimore to Pittsburg is $1.34, making a total cost, inclusive of the import duty of $3, of $7.38 to $7.74 per ton laid down at Pittsburg. The freight rate on American fluorspar to Pittsburg is $2.50 and to Philadelphia, $4.60. Domestic unwashed gravel spar can be sold at Pittsburg for about $7; hence, it can compete in that market with the English importations. At Philadelphia, however, it can not be sold under $8 or $9 per ton; hence, it cannot compete with the English spar which, inclusive of tariff, costs only $6.04 to $6.40 per ton laid down at that city. The declared value of the first imports was $3.11 per short ton, which proves the correctness of the above figures.

The tariff gives American fluorspar producers the advantage of trade at practically all the openhearth-steel furnaces, since few, if any, are sufficiently near Atlantic ports to take advantage of English importations. The effect of English competition will be felt until the large stock imported prior to the enactment of the tariff is exhausted, and American shippers are able to meet the demand. Prior to the tariff, English fluorspar sold at Pittsburgh at $5.85 per ton. Since the maximum amount of fluorspar used in the manufacture of a ton of steel is 15 lb., it is apparent that the increased cost per ton of steel produced does not exceed 1½ cents.

The imports prior to the tariff were variously estimated at from 30,000 to 100,000 tons per year. There are no records to show how much of the waste-dump fluorspar was produced since the British Government does not require reports of production from openings less than 20 ft. deep. The imports of fluorspar from Aug. 5, to Sept. 30, 1909, under the new tariff, according to preliminary figures amounted to only 344 tons valued at $1412.

New Developments.—No developments were reported from Arizona, but New Mexico was a producer for the first time. In southwestern New Mexico fluorspar veins traverse limestone and shale and the American Fireman's Mining Company opened one of these at Mirage, Luna county, near Deming. The fluorspar is lump and said to run 90 per cent. calcium fluoride.

So far as could be learned, operations in Colorado were limited to a few mines in Jefferson and Boulder counties. In the former county R. A. Gurley is running a tunnel 300 ft. to intersect his copper fluorspar vein at a greater depth and expects to mine a large tonnage in 1910.

TABLE III. FLUORSPAR OUTPUT OF THE PRINCIPAL PRODUCING COUNTRIES.
(In metric tons.)

Year.	France.	Germany.	Spain.	United Kingdom.	United States.
1897	2,722	23,232	2	302	3,973
1898	3,077	23,787	5	57	11,021
1899	5,140	24,306	310	796	21,806
1900	3,430	30,310	4	1,471	19,646
1901	3,970	28,741	*Nil.*	4,232	17,768
1902	2,650	(*a*)14,177	93	6,388	47,190
1903	2,447	(*a*)13,028	4,000	12,102	38,577
1904	2,047	(*a*)13,540	(*b*)	18,451	33,069
1905	2,434	(*a*)15,019	(*b*)	40,079	(*c*)35,299
1906	4,218	(*a*)15,493	70	42,521	(*c*)28,657
1907	4,795	(*a*)16,624	270	50,257	(*c*)32,969
1908	5,456	(*a*)14,925	253	35,257	(*c*)35,738
1909	(*b*)	(*a*)14,545	(*b*)	....	(*d*)41,550

(*a*)Exports. German statistics no longer report production. (*b*)Not reported. (*c*)These statistics collected by *The Mineral Industry* differ slightly from those reported for the same year by F. J. Fohs in the preceding table. (*d*) Amount mined.

Kentucky operators have been rather inactive for two years or more, the companies awaiting better conditions. The imposition of the tariff has caused renewed activity to some extent. The Albany Mining and Investment Company sunk the Nancy Hanks mine to a depth of 340 ft. and reports the fluorspar to be 6 ft. wide at that depth with a 9-ft. shoot at the 330-ft. level. The Kentucky Fluorspar Company opened the Beck vein and found excellent fluorspar near the surface. At the Memphis incline development work was vigorously carried on to open new shoots. Arrangements are being made to reopen a number of their mines in 1910. The American Fluorspar Company recently began the development of properties on the Kentucky and Yandell veins. The Franklin Mining Company cut a 7-ft. shoot on the Ada Florence vein. James Persons developed a vein of fluorspar and zinc carbonate on the Ebbie Hodge property.

In central Kentucky further development work was done at the Twin Chimneys mine.

In Illinois, the Fairview Fluorspar and Lead Company sunk the Fairview incline to a depth of 520 ft. and intends continuing at the rate of 20 ft. per month. At the 460-ft. level a 20-ft. fluorspar shoot was opened. The new shaft 1200 ft. north is down 240 ft. and still sinking, and good spar is being mined from the 200-ft. level. The old No. 1 shaft was reopened and a 20-ft. shoot is being mined. The Rosiclare mine was developed materially so that it is ready for a large production in 1910. The Marion Lead and Fluorspar Company continued mining at the Stewart mine near Shetlerville, and the Cave-in Rock Mining Company near Lead Hill. The Fairview mill is being rebuilt with a view of increasing its capacity to 300 tons per day, installing three of the new pattern double-plunger Foust jigs, and conveying belts for handling finished products. The Rosiclare has two new Foust jigs, and adequate additional power equipment.

The Kentucky-Illinois district needs a customs plant for the separation of zinc and fluorspar. A number of methods such as the Sanders flotation process or a combination of tabling and a Keedy ore sizer, might be practically applied.

Uses.—The use of fluorspar is on the increase in the manufacture of glass, enamel and sanitary ware, electrolytic refining of antimony and lead, the production of aluminum and in the iron and steel industries. In the last, the value of fluorspar in small amounts in conjunction with limestone flux is becoming more and more appreciated. The increase in the number of open-hearth furnaces, and, hence, the increased production of basic open-hearth steel, is especially encouraging. Only in the manufacture of hydrofluoric acid (aside from that used in electrolysis) was there an apparent falling off in demand.

Bibliography.

The following papers relating to the fluorspar industry appeared in the technical press in 1909:

Anonymous. "Hydrofluoric Acid in the Foundry." (*Mechan. Wld.*, June 4, 1909; 1 p.)

Bretherton, H. G. "Available Lime (Calcium Fluoride) in Ores." (*Mex. Min. Journ.*, April, 1909; 1 p.)

Burchard, E. F. "Fluorspar in Colorado." (*Min. and Sci. Press.*, Aug. 21, 1909; 3 pp.)

Fohs, F. J. "Kentucky Fluorspar and Its Value in the Iron and Steel Industries." (*Trans.* A. I. M. E., April, 1909; pp. 411-423.) The second part of this paper on the use of fluorspar in iron and steel making may also be found in the following journals: *Iron and Coal Trades Rev.*, London, April 30, 1909; *Iron Age*, May 27, 1909, pp. 1692-1693; *Min. and Sci. Press*, June 26, 1909, pp. 888-890; *Min. Wld.*, June 26, 1909, pp. 1217-1220.

Fohs, F. J. "Fluorspar Grades and Markets." (*Min. and Sci. Press*, Nov. 27, 1909; 1¾ pp.)

Martin, H. G. "Barium and Sulphur in Fluorspar." (*Journ. Ind. and Eng. Chem.*, July, 1909; 2 pp.)

Norwood, Charles J. "Summary of Statistics, Kentucky Coal, Fluorspar, etc." (*Report*, Kentucky Geological Survey, August, 1909.)

FULLER'S EARTH.

The production of fuller's earth in the United States in 1909 showed a decrease of about 1000 tons as compared with the output in 1908. As in previous years, the bulk of the output came from Florida, with Georgia, Arkansas, Texas and California following in the order named. The principal producers were the Owl Commercial Company, Quincy, Fla.; Atlantic Refining Company, Philadelphia, Penn.; Lester Clay Company, Attapulgus, Ga.; Arkansas Fuller's Earth Company, Chicago, Ill., and the Southern Fuller's Earth Company, Warren, Penn. (mines and mill at Jamieson, Fla.).

The imports and production of fuller's earth in the United States during the last decade are shown in the accompanying table:

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Production.		Imports.		Year.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value
1900......	11,813	$70,565	9,154	$64,790	1905......	25,745	$157,776	15,181	$105,997
1901......	14,112	96,835	12,061	80,697	1906.....	28,000	237,950	14,827	[illegible]
1902......	14,100	109,980	15,135	102,580	1907.....	34,039	323,275	14,648	122,221
1903	29,693	190,277	17,100	120,67[illegible]	1908......	30,517	270,685	12,279	92,413
1904......	29,480	168,500	10,221	74,000	1909	29,561	289,000	11,406	101,151

During 1909 the Southern Fuller's Earth Company began development work on 400 acres of ground at Jamieson and 540 acres at Getzlaff, Fla., and commenced the erection of a plant at the latter place.

Prices and Commercial Conditions.—In the local markets sales of fuller's earth were made throughout the year at 80@85c. per 100 lb. in large lots. The average quotation for the year was 82½c., as compared with an average of 80c. in 1908. There was a heavy movement on existing contracts during the early part of 1909, but only a moderate amount of business was transacted during the summer. In the fall, however, trade picked up, and a number of good-sized orders were placed for immediate shipment to enable consumers to meet their current requirements. Under the Payne tariff the import duty on fuller's earth remained unchanged at $3 per ton for the wrought or manufactured product, and at $1.50 per ton for crude material. In spite of this duty English producers are able to compete in the American markets, on account of the comparatively low cost of mining and transportation, and superiority of their product. English fuller's earth is used almost exclusively in bleaching edible oils, the American product being unsatisfactory for this purpose. The domestic material, however, is far superior to the foreign product for decolorizing mineral oils and an increasing quantity of Florida fuller's earth is finding a market for this purpose in Europe, about 20 per cent. of the 1909 output having been exported.

The Fuller's Earth Deposits of Florida.

By E. H. Sellards.

Fuller's earth deposits, variable in character and thickness, are known in Florida from the Apalachicola river in western to Manatee county in southern Florida. The formation may originally have been continuous over this territory; at present, however, owing to decay and removal by erosion, the fuller's earth stratum is found interruptedly over much of the area. The deposits have been found to be associated with the Apalachicola group of formations, which is regarded as of Upper Oligocene age. The counties from which fuller's earth has been reported are Gadsden, Liberty, Leon, Wakulla, Alachua, Marion and Manatee.

Gadsden County.—This county lies in middle west Florida between the Apalachicola and Ockloocknee rivers. The interior of the county forms a plateau lying 250 to 300 ft. above the sea. This is crossed by the Seaboard Air Line Railroad from Quincy to Mt. Pleasant; by the Apalachicola Northern Railroad from Horsford to Hardaway; and by the Georgia, Florida & Alabama Railroad from Gibson to Havana.

The fuller's earth deposits of Gadsden county occur as strata interbedded between sandstones or bluish or yellowish sands, which vary in places to calcareous shell-bearing marls. The fuller's earth itself rarely contains fossils, but both vertebrate and invertebrate remains are occasionally found immediately above and below the fuller's earth. The following summary will indicate the relation of the fuller's earth to the overlying and underlying formations in Gadsden county:

7. Sand: Medium coarse, light or pale yellow, Pleistocene age, possibly of residual origin.....6 to 9 ft.
6. Red sand and sandy clays: Upper member is a coarse, cross-bedded sand-pebble conglomerate, varying in color from rich red to light red or gray; often strongly indurated; when weathered, becomes mottled to depth of 1 to 5 ft., with formation of indurated crusts. Near the middle occurs a stratum of iron concretions. Lower members are of coarser texture, and contain abundant brown-stained quartz pebbles.....20 to 28 ft.
5. Reddish sandy clay with white partings, passing downward into clays and finally into a greenish clay containing, alum.....60 to 70 ft.

The total thickness of the formation lying above the fuller's earth series, except where eroded.....100 ft.

4. Fuller's earth series: (See detailed sections) about.....20 ft.
3. Alum Bluff formation: Gray, blue and yellow calcareous sands.....100 ft.
2. Chattahoochee formation: Impure clayey limestones.
1. Vicksburg, Lower Oligocene, limestones: Not exposed in Gadsden county.

The fuller's earth stratum is very rarely level, sloping gently toward the south at a grade scarcely exceeding that of the stream fall. It underlies the whole of Gadsden county, except where eroded, and extends into Georgia on the north and into the adjoining counties on the south. Exposures are frequent.

The structure of the fuller's earth formation is indicated by the following sections:

OWL COMMERCIAL COMPANY'S PIT AT QUINCY.

6. Sandy, more or less decayed, mottled clays of varying thickness, lying unconformably on the stratum beneath, about	12 ft.
5. Bluish sand rock with some clay and occasional shell and marl inclusions	4 ft.
4. Fuller's earth	6 ft.
3. Sandstone, more firmly indurated than the above, and containing shells	5 ft.
2. Fuller's earth, about	6 ft.
1. Test pits indicate that the fuller's earth is underlain by sands or sandstones.	

PUBLIC ROAD ONE MILE EAST OF QUINCY.

5. Covered to the top of the hill.	
4. Greenish sticky clay	5 ft.
3. Fuller's earth, about	4 ft.
2. Calcareous sand rock with fossils	4½ ft.
1. Fuller's earth (exposed)	3 ft.

FIVE MILES NORTHEAST OF QUINCY, ON NORTH SIDE WILLACOOCHEE CREEK.

5. Covered to the top of the hill.	
4. Blue sand which, upon exposure, oxidizes yellow	6 ft.
3. Fuller's earth, about	6 ft.
2. Sandstone, about	4 ft.
1. Fuller's earth (exposed)	1 ft.

ONE MILE WEST OF GATZLAFF, ON WEST SIDE ATTAPULGUS CREEK.

5. Covered to top of the hill.	
4. Fuller's earth, about	5 ft.
3. Sandstone	2½ ft.
2. Fuller's earth, about	8 ft.
1. Sandstone, about	8 ft.

PUBLIC ROAD FROM NICHOLSON TO LITTLE RIVER.

10. Superficial sands	10 ft.
9. Red sands	36 ft.
8. Covered	5 ft.
7. Nicely laminated clays	11½ ft.
6. Buff colored clay	4 ft.
5 Partly covered, with occasional sand and sandy clay exposures	4½ ft.
4. Sands containing some carbonaceous material	8 ft.
3. Blue fuller's earth	5 ft.
2. Gray sandstone	10 ft.
1. Covered to the bed of the river, about	10 ft.

Liberty County.—This county lies between the Ocklocknee and the Apalchicola rivers, south of Gadsden county and reaches to within about 15 miles of the gulf coast. Except for an increased thickness of superficial sands, northern Liberty county is similar both geologically and topographically to the adjoining parts of Gadsden county. Passing south, the surface falls off gradually until at Bristol it lies not more than 100 ft. above the river, and a few miles beyond Bristol, the lowlands of the coastal region appear. The Chattahoochee limestone passes beneath the river at Rock Bluff. On Rock creek and Sweetwater creek and its tributaries, the blue and calcareous sands of the Rock Bluff section are exposed. Fuller's earth occurs at Rock Bluff and along the head waters of Rock and Sweetwater creeks.

Leon County.—This county lies to the east of Gadsden and differs from it in some important respects. In Leon county, limestone lies nearer the surface than in Gadsden. The result is the formation, by solution, of large lake basins like lakes Jackson, Lafayette, Iamonia, and Miccouskee. The drainage is largely subterranean, and underground solution therefore predominates over surface erosion.

The red sands corresponding to the red sands of Gadsden county are medium coarse, but not so coarse as those found along the Apalachicola. The clays beneath these sands are less conspicuously developed and are absent in places. Inclusions of a gray calcareous sandstone in the red sands are very numerous. In Leon county the fuller's earth has been traced as far east as Tallahassee, and is also found 13 miles west of Tallahassee. The deposits here overlie gray calcareous sands similar to the sands at Rock Bluff. Fuller's earth may be expected along the Ocklocknee river to the southern line of the county.

Wakulla County.—This county lies to the south of Leon, bordering the gulf coast. The Alum Bluff sands are found in the western part, being exposed along the Ocklocknee and Sopchoppy rivers, and their tributaries. The fuller's earth deposits, which lie at the top of this formation, have been observed between these two rivers and may be expected to occur at other localities in the northwestern part of the county.

Alachua County.—The occurrence of fuller's earth in the Devil's Millhopper, six miles northwest of Gainesville, was known as early as 1901. The following section was made at this place. The top of this section is about 180 ft. above sea level.

SECTION AT DEVIL'S MILLHOPPER.

7.	Covered and sloping	25 ft.
6.	Yellowish phosphatic limestone	15 ft.
5.	Bluish-green sandy marl	8 ft.
4.	Gray and blue sands with some impure fuller's earth	40 ft.
3.	Yellowish limestone	13½ ft.
2.	Sandstone	4½ ft.
1.	White limestone, weathering yellow	5 ft.
		111

At the city pumping plant two and a half miles southeast of Gainesville, fuller's earth was also observed. The fuller's earth here is associated with a calcareous sandstone.

Marion County.—Fuller's earth has been reported from Fairfield and Kendrick in the northern part of the county. Samples were obtained from a sink, known locally as the "Grotto," near Belleview, in the southern part of the county. The section at this point is as follows:

SECTION AT SINK NEAR BELLEVIEW.

7.	Yellowish sand	4 ft.
6.	Yellowish sandy clay	15 ft.
5.	Covered and sloping	21½ ft.
4.	Decayed limestone with fuller's earth inclusions	7½ ft.
3.	Fuller's earth	4¾ ft.
2.	Gray sand	3½ ft.
1.	Phosphatic sandy limestone, containing rounded, dark colored, phosphatic pebbles	2½ ft.

Manatee County.—This county lies along the gulf coast of southern peninsular Florida, and is comparatively level and of but slight elevation. Manatee river crosses near the northern part and Miakka river through the southern part of the county, entering Charlotte harbor. Fuller's earth has been mined for several years near Ellenton.

The stratigraphy of this district may be summarized thus:

7. Surface sands, usually loamy .... 1 to 2 ft.
6. Peat, variable in thickness, but rarely absent.
5. Sandy, sometimes clayey, stratum, variable but persistent.
4. Conglomerate, containing bones and pebbles. Traces can almost always be found .... 0 to 2 ft.

Erosion unconformity.

3. Calcareous bed of variable composition and thickness: Where it is in the nature of a calcareous, sandy clay, it varies from 1 to 5 ft.; where it is an impure marly limestone, it is 4 or 5 ft. thick. The variation is sometimes very abrupt. The bed contains a few fossils. It rests conformably upon and grades into the fuller's earth.
2. Fuller's earth .... 0 to 7 ft.
1. Marly limestone, close-grained, containing a few fossil shells.

The following section of the fuller's earth formation was obtained in the Atlantic Refining Company's pit:

SECTION IN PIT OF ATLANTIC REFINING COMPANY.

7. Dark colored sandy soil .... 1 ft.
6. Dark carbonaceous stratum .... 1 ft.
5. Bone stratum containing manatee ribs and other bone fragments .... 2 ft.
4. Unconformity.
3. Sandy calcareous stratum with gravels .... 4 ft.
2. Fuller's earth .... 8 ft.
1. Close grained marl.

SECTION IN PROSPECT HOLE, NORTH OF PIT.

5. Sand and soil .... 1 ft.
4. Bone pebble stratum .... 1 to 2 ft.
3. Unconformity.
2. Marly limestone .... 9 to 10 ft.
1. Fuller's earth.

The following section was obtained at the abandoned pit of the Columbia Fuller's Earth Company, about two miles northeast of Ellenton:

SECTION IN PIT OF COLUMBIA FULLER'S EARTH COMPANY.

Surface sand and soil .... $1\frac{3}{4}$ ft.
Dark carbonaceous sands .... $1\frac{3}{4}$ ft.
Blue calcareous clay, with occasional bone fragments .... 4 ft.
Fuller's earth, reported to be .... $6\frac{1}{2}$ to 7 ft.

The fuller's earth of Manatee county, like that of Gadsden county, is probably of Upper Oligocene age.

Technology of Fuller's Earth.

Fuller's earth is an aluminum silicate containing more combined water than most clays; its chemical composition varies with its origin, and is of no value in the matter of determining the commercial qualities of a given sample. In color, fuller's earth is commonly brown or gray, but it also occurs white, yellow, pale red, and even black. Its specific gravity ranges from 1.75 to 2.50. The best earth comes from Dorset, Kent and Surrey counties, England.

When analyzed by the methods applied to rocks, some fuller's earths show a strongly acid reaction, although entirely free from acids. This apparent acidity arises from its absorptive qualities, and is directly proportional to its power of absorbing such bases as lime; it is not, however, at all proportional to its decolorizing power on oils. The apparent acidity varies from nothing up to the point at which 1.50 per cent. of oxide of lime is required to neutralize it.

Decolorization and Oxidizing Power.—Fuller's earths from certain localities have the unfortunate effect of giving to edible oils a rancid flavor, by oxidation, and this power is directly proportional to the absorbing capacity of such earth. Earths which possess this character to a high degree can be treated with limewater, to counteract the apparent acidity, but at the same time their decolorizing power will be diminished; it is for this reason that earths high in lime are not good decolorizers. If the above treatment be limited to the partial neutralization of the acidity, the odorizing effect of the earth will be reduced while its decolorizing power will not be entirely lost.

When an earth of high apparent acidity is subjected, under water, to a strong electric current, the particles appear to be negatively charged, and move slowly toward the positive pole; this probably explains the fact that such earths give an acid filtrate after agitation with salt water, and have the power to remove the nitrogenous colors from an oil, exactly as would be done by a true acid.

Some earths possess a very active oxidizing power on oils; the oxidation is sometimes so violent that the cakes removed from a filter press, after treatment of an oil, will burst into flames from spontaneous combustion as soon as they reach the air. This event is most often noticed when working with rapid-drying oils.

The decolorizing power of fuller's earth has never been perfectly explained; some think that it is a chemical reaction, while others believe it to be purely mechanical. Cameron's experiments seem to indicate that it is merely an absorption, and that it takes place more rapidly in an oil than in a water solution. Practically all the coloring matter taken out of an oil by a fuller's earth can be recovered from the earth by alcohol, provided that the adherent oil is first removed by treatment with ether or benzine. This combined treatment will restore the decolorizing power of a used earth almost completely.

Treatment of Mineral Oils.—The decolorizing of mineral oils is conducted in a different way, and with a different quality of earth, than that applied to animal and vegetable oils. For mineral oils, the Florida fuller's earth seems better than the English, and even an important amount of lime is no detriment. The operation is similar to that of clarifying sugar solutions by boneblack, consisting in allowing the oil to filter through a bed of fuller's earth. The first oil to come through will be almost colorless; thereafter it comes through less and less clear, until the filter bed becomes saturated with coloring matter and will absorb no more. The spent earth can then be regenerated by calcining in a rotary furnace; the high temperature to which it is subjected here does not seem to diminish its decolorizing power on mineral oils, though it does with animal and vegetable oils. The fineness of the earth should be adapted to the nature of the oil to be treated; heavy and viscous oils require the earth to be in coarse grains, while with a light oil, the earth can be ground to 200 mesh and over.

Animal and Vegetable Oils.—The method of decolorizing animal and vegetable oils is to heat the oil in a receptacle containing a coil of steam pipe; add the necessary amount of fuller's earth; stir for two or three minutes, and conduct the mixture to a filter press to recover the earth and liberate the oil. The temperature varies according to the nature of the oil and the kind of product desired, but ranges around 100 deg. C. A lower temperature is often used.

The amount of earth required also depends upon the nature of the oil, and even for different lots of an oil of the same general nature, different amounts of earth will be required to yield a product of the desired whiteness. Lard oil generally requires 1 per cent., by weight, of fuller's earth, cottonseed oil requires 5 per cent., while tallows need very large proportions. The oil refiner selects his stocks of crude material so as to demand the least possible amount of fuller's earth to decolorize it, since he will thus not only economize in the consumption of earth, but will also lose less oil by adherence to the earth.

GARNET.

The Adirondack region of New York continues to be the only district in the United States producing garnet for abrasive purposes. The industry is confined to Warren and Essex counties. North Creek, the terminus of the Adirondack branch of the Delaware & Hudson Railroad is the principal point of shipment. The garnet is the iron-aluminum variety known as almandite and occurs as crystals in a metamorphosed amphibole. The rock, mined by ordinary quarry methods, is crushed sufficiently fine to liberate the garnet, which is then recovered either by hand sorting or by mechanical concentration in jigs. The entire output is used in the form of garnet paper in the shoe and wood-working industries. The amount and value of the garnet produced in the United States for a period of years is shown in the accompanying table:

PRODUCTION OF GARNET IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Short Tons.	Value.	Value per Ton.	Year.	Short Tons.	Value.	Value per Ton.
1900	3,285	$ 92,801	$28.25	1905	3,694	$114,625	$31.01
1901	4,444	158,100	35.51	1906	5,404	179,548	33.22
1902	3,722	122,826	33.00	1907	6,723	209,895	31.22
1903	4,413	146,955	33.30	1908	2,530	78,090	30.86
1904	2,952	89,636	30.36	1909	3,802	121,700	32,01

New York. (By D. H. Newland.)—The year 1909 was somewhat disappointing for the abrasive garnet trade. Though conditions on the whole were a little more favorable than in the preceding year, a radical change for the better seemed in order after such an extreme depression as that experienced throughout 1908. But the market continued dull during most of the twelve months. It did not appear that garnet was being displaced by other abrasive materials, or that the local producers were meeting increased competition from outside sources of supply, so that a renewal of former activity should be forthcoming in the course of time. As the existing mines have never been worked to their capacity, there will be no immediate need apparently for any addition to the present productive facilities.

The output from the Adirondack mines last year amounted to 3802 short tons valued at $121,700. This represented a material gain over the total of 2530 tons reported in 1908 and would have been fairly satisfactory if the market had expanded at a corresponding rate. The mines held, however, a considerable part of the output in stock at the close of the year. As it was, the total fell about 2000 tons short of the record for 1907. Prices remained practically unchanged; in fact they have never been subject to marked fluctuations.

The list of active companies included the North River Garnet Company, American Glue Company, and H. H. Barton & Son, with mines near North River, and the American Garnet Company with a mine on Mt. Bigelow in northern Essex county. The property of the last-named company was worked under a lease by Mr. E. Schaaf Regelman, of New York. The North River Garnet Company is the only producer making use of mechanical methods of separation. It owns literally a mountain of garnet rock and its mill could readily supply the entire present requirements of the domestic trade or any demand that is likely to be developed in the near future.

GLASS.

At the beginning of 1909 the window glass industry was in an unsatisfactory condition. A majority of the plants were closed down, owing to a strike for a 25-per cent. increase in wages which was declared in December, 1908. In February the strike was practically broken, many of the men resuming work, and by March most of the plants were again in operation. Contrary to expectations, however, trade demands showed no appreciable sign of improvement, and considerable stocks were accumulated. More or less price cutting resulted, and it was reported that a number of factories were selling at a loss in order to meet their payrolls. In view of the very unsatisfactory condition of the market just at the time when demand should have been the best, an attempt was made to form a selling agency to regulate prices, this agency to be known as the Imperial Window Glass Company. This project failed, however, due to the refusal of a number of companies to become affiliated with the agency. There was no change in market conditions until June, when there was a slight improvement in the demand, and quotations were somewhat firmer. During the summer months, practically all the factories were closed. Operations were resumed on a considerable scale during September, and the fall trade was of fair proportions, although there was a considerable surplus stock. In December, after numerous unsuccessful attempts during the preceeding 18 months, the Imperial Window Glass Company was formed. The market responded at once to the control of this agency, and at the close of the year was in a firm condition. Prices as recommended by the Eastern Window Glass Jobbers' Association from the jobbers' list of October 1, 1903, were as follows: New England States and New York, single, 90 and 25 per cent. off, and double, 90 and 30 per cent. off.

GOLD AND SILVER.

The output of the world's gold mines in 1909 surpassed that in any previous year, and exceeded the yield of 1908 by 3 per cent. The leading contributors to the increase were Russia, the Transvaal, and the United States; Rhodesia, India, Mexico, and Canada maintained approximately the same production as in 1908; while Australia and West Africa were the only large producers to afford notably diminished outputs.

Nevada was the heaviest contributor to the increase in the United States, due not so much to new discoveries as to the more efficient operation of its many large mines. California contributed heavily to the surplus output of 1909, followed by Alaska. Colorado retained its position as the leading gold producing State of the Union, closely followed by California and Alaska.

PRODUCTION OF GOLD IN THE UNITED STATES. (*a*)

States.	1906		1907		1908.		1909.	
	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value (*b*)	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)
Alabama	1,137	$23,500	1,325	$27,400	1,993	$41,200	1,354	$28,000
Alaska	1,033,537	21,365,100	894,424	18,489,400	959,755	19,858,800	1,013,430	20,947,600
Arizona	132,891	2,747,100	128,871	2,664,000	120,948	2,500,000	129,284	2,672,300
California	911,041	18,832,900	815,288	16,853,500	935,157	19,329,700	1,029,090	21,271,300
Colorado	1,109,452	22,934,400	1,010,921	20,897,600	1,106,483	22,871,000	1,062,153	21,954,700
Georgia	1,146	23,700	3,135	64,800	2,719	56,200	2,144	44,300
Idaho	50,102	1,035,700	60,754	1,255,900	69,835	1,443,500	67,214	1,389,300
Montana	218,752	4,522,000	167,987	3,472,600	152,879	3,160,000	174,137	3,599,400
Nevada	448,852	9,278,600	745,507	15,411,000	565,525	11,689,400	721,258	14,908,400
New Mexico	12,877	266,200	15,964	330,000	14,819	306,300	13,464	278,300
N. Carolina	4,397	90,900	3,807	78,700	4,717	97,500	1,558	32,200
Oregon	63,860	1,320,100	59,124	1,222,200	43,827	905,900	34,489	712,900
S. Carolina	3,609	74,600	2,811	58,100	2,598	53,700	169	3,500
S. Dakota	319,512	6,604,900	200,185	4,138,200	374,562	7,742,200	331,393	6,849,900
Tennessee	39	800	184	3,800	179	3,700	179	3,700
Texas	164	3,400	48	1,000	24	500	19	400
Utah	248,208	5,130,900	247,758	5,121,600	190,938	3,946,700	186,009	3,844,800
Virginia	498	10,300	402	8,300	174	3,600	174	3,600
Washington	4,983	103,000	12,689	262,300	12,274	253,700	18,282	377,900
Wyoming	276	5,700	455	9,400	368	7,600	184	3,800
Other States	....	....	....	....	179	3,700	5,767	119,200
Total	4,565,333	$94,373,800	4,371,639	$90,369,800	4,560,953	$94,274,900	4,791,751	$99,045,500
Porto Rico	....	....	58	1,200	29	600	29	600
Philippine Islands	....	....	3,130	64,700	13,764	284,500	9,003	186,100
Total	4,565,333	$94,373,800	4,374,827	$90,435,700	4,574,746	$94,560,000	4,800,783	$99,232,200

(*a*) The statistics in this table are as reported by the Director of the Mint, those for 1909 being the preliminary figures (subject to revision). (*b*) At $20.67 per oz.

The production of silver in the world during 1909 showed an increase over that of the preceding year. Canada accounted for most of it, while the United States and Mexico contributed to a smaller extent and about equally to the increase over 1908. The output of the United States, though greater in 1909 than in 1908, was still below that of any other year since 1897. The Cobalt district of Ontario was responsible for most of the enlarged silver output of Canada, though the increase was not relatively as great as that of 1908 over 1907. The increase in the United States was attributable to the enlarged output of copper ores in Montana, Utah and Arizona, from which a large part of the silver production is obtained.

PRODUCTION OF SILVER IN THE UNITED STATES. (*a*)

States.	1906		1907		1908.		1909.	
	Fine Ounces.	Commercial Value. (*d*)	Fine Ounces.	Commercial Value. (*d*)	Fine Ounces.	Commercial Value. (*d*)	Fine Ounces.	Commercial Value. (*d*)
Allabama	100	$67	(*c*)	....	400	$211	200	$103
Araska	203,500	135,920	179,250	$118,300	204,600	108,160	158,100	81,425
A izona	2,969,200	1,983,158	2,903,050	1,916,000	2,900,000	1,533,056	3,632,200	1,870,656
California	1,517,500	1,013,553	1,590,000	1,049,400	1,703,700	900,644	1,705,200	878,212
Colorado	12,447,400	8,313,743	11,494,500	7,587,000	10,150,200	5,365,802	9,093,600	4,683,386
Georgia	300	200	(*c*)	....	200	106	200	103
Idaho	8,836,200	5,901,786	7,888,400	5,206,300	7,558,300	3,995,620	7,054,500	3,633,209
Illinois	(*c*)	....	(*c*)	....	2,000	1,057	3,600	1,854
Michigan	186,100	124,298	331,350	218,700	294,100	155,473	323,900	166,814
Missouri	(*c*)	....	25,150	16,700	49,400	26,115	15,200	7,828
Montana	12,540,300	8,375,792	11,129,600	7,345,500	10,356,200	5,474,702	12,000,000	6,180,240
Nevada	5,207,600	3,478,208	8,250,450	5,465,100	9,508,500	5,026,573	8,953,000	4,610,974
N. Mexico	453,400	302,830	599,550	395,700	400,900	211,932	329,200	169,545
N. Carolina	24,700	16,497	25,150	16,600	1,300	687	500	257
Oregon	90,700	60,579	96,050	63,400	56,100	29,657	71,100	36,618
S. Dakota	155,200	103,658	106,600	70,400	197,300	104,301	205,600	105,888
Tennessee	25,600	17,098	58,350	38,500	60,900	32,494	58,500	30,129
Texas	277,400	185,278	305,300	201,500	447,000	236,302	358,300	184,532
Utah	11,508,000	7,686,298	11,406,800	7,528,500	8,451,300	4,467,695	9,533,400	4,909,892
Virginia	100	67	(*c*)	....	300	158	6,000	3,090
Washington	42,100	28,119	83,950	55,400	86,800	45,886	73,500	37,854
Wyoming	1,100	735	(*c*)	....	3,500	1,850	1,100	566
Other States	31,300	20,906	10,000	6,600	6,500	3,436	270,000	139,055
Total	56,517,900	$37,748,757	56,514,550	$37,299,600	52,439,500	$27,721,617	53,846,900	$27,732,231
Philippine Islands	....	....	150	99	1,300	687	2,100	1,082
Total	56,517,900	$37,748,757	56,514,700	$37,299,699	52,440,800	$27,722,304	53,849,000	$27,733,312

(*a*) The statistics in this table are reported by the Director of the Mint, those for 1909 being the preliminary figures (subject to revision). (*c*) Included in other States. (*d*) Based on the average value for the year at New York, as follows: 1906, 66.791 c.; 1907, 65.327 c.; 1908, 52.864 c.; 1909, 51.502 c. per oz.

Gold and Silver Mining in the United States.

Much of the gold and silver produced in the United States, as elsewhere in the world, is derived from the ores of copper and lead. According to its usual custom, The Mineral Industry will review the output of those base metals under appropriate captions elsewhere in this volume. The following reviews relate only to the mines of gold and silver proper.

Alaska.—The output of gold from Alaska during 1909 was valued at $20,947,600, an increase of $1,088,800 over that of the preceding year. The lode mines on Douglas island contributed $3,400,000 to the total for 1909, an increase of $40,000 over their quota in 1908; that is, so far, the only gold in Alaska obtained on a large scale by lode mining. As to the sources of the placer gold, the receipts at the United States assay office in Seattle during 1909 included $4,239,416 from Nome, $6,204,573 from Tanana, and $863,592 from the rest of Alaska, a total of $11,307,-581, which, of course, does not represent the entire yield of that territory, as some of the gold goes to other receiving points. Of the $188,128,872, which has been received at the Seattle office since July, 1898, Nome has furnished $42,264,228; Tanana, $37,329,157; and the remainder of Alaska, $7,865,248.

TOTAL PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES.

Years.	Gold.	Silver.	Years.	Gold.	Silver.	Years.	Gold.	Silver.
	Dollars.	*Ounces.*		*Dollars.*	*Ounces.*		*Dollars.*	*Ounces.*
1792-1834...	14,000,000	*Nil.*	1884.	30,800,000	37,800,000	1898.	64.463,000	54,438,000
1835-1844...	7,500,000	193,365	1885.	31,800,000	39,910,000	1899.	71,053,000	54,764,000
1845-1854...	343,036,769	386,730	1886.	35,000,000	39,685,513	1900.	79,171,000	57,647,000
1855-1864...	479,300,000	20,806,518	1887.	33,000,000	41,721,592	1901.	78,666,700	55,214,000
1865-1874...	454,950,000	154,390,609	1888.	33,175,000	45,792,682	1902.	80,000,000	55,500,000
1875........	33,400,000	24,533,993	1889.	32,800,000	50,000,773	1903.	73,591,700	54,300,000
1876........	39,900,000	30,010,054	1890.	32,845,000	54,516,300	1904.	80,723,200	57,786,100
1877........	46,900,000	30,783,509	1891.	33,175,000	58,330,000	1905.	88,180,700	56,101,600
1878........	51,200,000	34,960,000	1892.	33,000,000	64,900,000	1906.	94,373,800	56,517,900
1879........	38,900,000	31,550,000	1893.	35,955,000	60,000,000	1907.	90,435,700	56.514,700
1880........	36,000,000	30,320,000	1894.	39,500,000	49,500,000	1908.	94,560,000	52,440,800
1881........	34,700,000	33,260,000	1895.	46,610,000	55,727,000	1909.	99,232,200	53,849,000
1882........	32,500,000	36,200,000	1896.	53,088,000	58,835,000			
1883........	35,000,000	35,730,000	1897.	57,363,000	53,860,000	Total	3,164,848,769	1,836,622,322

Note.—To the end of 1872 the statistics are those of R. W. Raymond, United States Mining Commissioner; subsequent statistics are those reported by the Director of the Mint. 1909 figures provisional.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493-1850.
According to Dr. Adolph Soetbeer.

Period.	Estimated Production In Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production In Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1741–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

The following details are abstracted from a report by Alfred H. Brooks for the United States Geological Survey on the mining industries of Alaska during 1909.

The placer camps of the Yukon basin were the scene of much activity in 1909. Two new dredges were put in operation near Nome, material progress was made in constructing a railway up the Copper River valley, and some work was done on the railway to the Matanuska district. The most significant feature of the year's operations was the amount of prospecting and development work done on auriferous lodes in some of the placer districts.

Lode Mining.—Of the auriferous lode mines operated in 1909 all but five are in the Juneau district. The Treadwell group continues to be the dominating factor in lode production, but some other large enterprises have either, like the Perseverance, become productive or, like the Ebner and Kensington, will soon be producers. A large producer-gas plant is being established near Juneau by the Perseverance company, and the Ebner mine has been taken over by a new company and is to be opened up on a large scale. There is promise that the protracted litigation over the Kensington mine and other properties at Berners Bay will soon be settled, and extensive developments are expected in this field at an early date.

The most encouraging events of the year were the discovery of promising lode prospects in many of the gold placer districts. Notable among

GOLD PRODUCTION OF THE WORLD, 1851-1908.

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1851.......	$67,600,000	1866......	$121,000,000	1881......	$103,102,000	1896......	$211,242,081
1852.......	132,800,000	1867......	104,000,000	1882......	102,000,000	1897......	237,833,984
1853.......	155,500,000	1868......	109,700,000	1883......	95,400,000	1898......	287,327,833
1854.......	127,500,000	1869......	106,200,000	1884......	101,700,000	1899......	311,505,947
1855.......	135,100,000	1870......	106,900,000	1885......	108,400,000	1900......	258,829,703
1856.......	147,600,000	1871......	107,000,000	1886......	106,000,000	1901......	260,877,429
1857.......	133,300,000	1872......	99,600,000	1887......	105,775,000	1902......	298,812,493
1858.......	124,700,000	1873......	96,200,000	1888......	110,197,000	1903......	329,475,401
1859.......	124,900,000	1874......	90,800,000	1889......	123,489,000	1904......	349,088,293
1860.......	119,300,000	1875......	97,500,000	1890......	118,848,700	1905......	378,411,754
1861.......	113,800,000	1876......	103,700,000	1891......	130,650,000	1906......	405,551,022
1862.......	107,800,000	1877......	114,000,000	1892......	146,292,600	1907......	416,101,396
1863.......	107,000,000	1878......	119,000,000	1893......	158,437,551	1908......	443,355,856
1864.......	113,000,000	1879......	109,000,000	1894......	182,509,283	1909......	459,486,282
1865.......	120,200,000	1880......	106,600,000	1895......	198,995,741	....	....

SILVER PRODUCTION OF THE WORLD, 1851-1908.

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1851-1855..	4,430,575	1881......	2,592,639	1891......	4,479,649	1901......	5,438,443
1856-1860..	4,534,950	1882......	2,769,065	1892......	4,985,855	1902......	5,121,469
1861-1865..	5,505,575	1883......	2,746,123	1893......	5,339,746	1903......	5,386,044
1866-1870..	6,695,425	1884......	2,788,727	1894......	5,205,065	1904......	5,669,124
1871-1875..	9,847,125	1885......	2,993,805	1895......	5,667,691	1905......	5,638,183
1876.......	2,323,729	1886......	2,902,471	1896......	5,496,178	1906........	5,683,947
1877.......	2,388,612	1887......	2,990,398	1897......	5,663,304	1907........	5,704,083
1878.......	2,551,364	1888......	3,385,606	1898......	5,575,336	1908........	6,612,304
1879.......	2,507,507	1889......	3,901,809	1899......	5,529,024	1909........	6,768.269
1880.......	2,499,998	1890......	4,180,532	1900......	5,599,216	....	....

GOLD PRODUCTION OF THE WORLD.

Countries.	1907. Oz. Fine.	1907. Kilo-grams.	1907. Value.	1908. Oz. Fine.	1908. Kilo-grams.	1908. Value.	1909. Oz. Fine.	1909. Kilo-grams.	1909. Value.
America, North:									
United States...	(a)4374,827	136,075	$90,435,700	(a)4574,746	142,275	$94,560,000	(a)4800,783	149,304	$99,232,200
Canada.........	(a) 405,517	12,612	8,382,780	(a) 476,112	14,807	9,842,105	(e) 486,219	15,121	10,050,000
Newfoundland...	4,315	134	89,191	(e) 4,300	134	88,881	(e) 4,300	134	88,881
Mexico.........	(a) 903,704	28,109	18,679,562	(a) 993,885	30,914	20,543,603	(a)1089,113	33,876	22,511,966
Central America.	(b) 101,980	3,172	2,096,911	(b) 146,034	4,542	3,018,793	(e) 175,000	5,442	3,617,250
America, South:									
Argentina.......	(b) 4,983	155	103,013	(b) 7,801	243	161,261	(e) 8,000	249	165,360
Brazil..........	146,218	4,548	3,022,326	(b) 106,259	3,305	2,196,568	(e) 110,000	3,421	2,273,700
Chile (f)........	(a) 61,310	1,907	1,267,278	16,752	521	346,300	(e) 15,000	466	310,050
Colombia.......	(b) 157,471	4,898	3,255,311	(a) 145,649	4,530	3,010,565	(e) 150,000	4,660	3,100.500
Ecuador........	(b) 12,924	402	267,169	(b) 16,945	527	350,300	(e) 17,000	529	351,390
Guiana, British..	59,796	1,859	1,234,988	62,406	1,941	1,289,948	(g) 54,660	1,700	1,129,811
Guiana, Dutch...	35,494	1,104	733,718	38,790	1,210	810,829	(e) 39,000	1,213	806,130
Guiana, French..	(a) 130,433	4,057	2,696,282	(a) 138,245	4,300	2,857,780	(e) 144,675	4,500	2,990,700
Peru...........	(a) 24,981	777	516,394	(b) 24,890	774	514,500	(e) 24,750	770	511,582
Uruguay........	(b) 2,508	78	51,839	(b) 4,433	138	91,600	(e) 4,019	125	83,075
Venezuela.......	(b) 1,093	34	22,596	(b) 1,184	37	24,500	(e) 1,200	37	24,804
Europe:									
Austria.........	4,565	142	94,359	4,790	149	99,009	(e) 4,822	150	99,690
France..........	(a) 40,991	1,275	847,290	(a) 55,491	1,726	1,146,999	(e) 57,870	1,800	1,196,280
Hungary........	111,073	3,454	2,295,854	104,386	3,246	2,157,639	(e) 106,095	3,300	2,193,180
Germany.......	(a) 150,526	4,682	3,111,372	(a) 152,970	4,758	3,161.890	(e) 154,320	4,800	3,189,794
Italy...........	(a) 1,625	51	33,582	1,932	60	39,930	(e) 2,090	65	43,199
Russia..........	1,282,635	39,895	26,512,065	1,497,098	46,560	30,944,561	1,812,448	56,367	37,455,032
Portugal........	48	1	1,000	1,833	57	37,888	(e) 1,500	47	31,005
Spain...........	322	10	6,645	....	....	....	....	....	....
Sweden.........	(a) 900	28	18,590	(a) 702	22	14,500	(e) 804	25	16,615
Turkey.........	(b) 225	7	4,652	(b) 108	3	2,200	(e) 161	5	3,323
United Kingdom	1,414	44	29,200	772	24	16,000	600	19	12,402
Africa:									
Madagascar.....	54,012	1,680	1,116,428	(b) 88,210	2,743	1,823,464	(e) 119,982	3,731	2,480,000
Rhodesia.......	(a) 512,791	15,959	10,589,386	(a) 593,932	18,471	12,276,389	(a) 616,904	19,186	12,751,226
Transvaal.......	(a)6443,353	200,388	133,182,167	(a)7043,837	219,063	145,593,985	(a)7271,482	226,143	150,299,329
West Coast......	271,496	8,444	5,611,741	278,031	8,647	5,746,825	224,695	6,988	4,644,386
Asia:									
Borneo, British..	(b) 75,520	2,349	1,561,145	(b) 67,770	2,108	1,400,000	(e) 70,730	2,200	1,462,120
China..........	(b) 217,688	6,771	4,500,000	(g) 314,470	9,780	6,500,000	(e) 241,900	7,523	5,000,000
E. Indies, Dutch.	(b) 79,636	2,477	1,646,214	108,641	3,379	2,245,609	141,899	4,413	2,933,000
India..........	500,057	15,552	(a) 10,336,034	518,360	16,121	(a) 10,714,336	518,875	16,137	(e) 10,725,000
Japan (d).......	(a) 92,100	2,864	1,903,681	(a) 112,795	3,508	2,331,444	(e) 112,525	3,500	2,326,100
Korea..........	(b) 105,002	3,266	2.170,584	108,502	3,385	2,250,000	(e) 110,000	3,421	2,273,700
Malay States....	15,627	485	325,000	(b) 13,581	422	280,734	(e) 14,468	450	299,070
Australasia (c)...	3,659,693	114,132	75,849,349	3,546,912	110,309	73,314,671	3,447,227	107 209	71,254,182
Other Countries.	72,570	2,257	1,500,000	75,000	2,332	1,550,250	75,000	2,332	1,550,250
Total.......	20,121,423	626,134	$416,101,396	21,448,554	667,071	$443,355,856	22,230,116	691,358	$459,486,282

(a) Official statistics of the country. (b) United States Mint Report. (c) Six States and New Zealand. (d) Exclusive of Formosa. (e) Estimated. (f) Includes Bolivia. (g) Exports.

these are the auriferous quartz veins found near Seward on Kenai peninsula, on Willow creek, in the Susitna basin, near Fairbanks, in the Koyukuk and Chandlar valleys and in the Bonnifield district. Auriferous veins have been found at several places on Kenai peninsula, and the prospecting on some of them during the year has yielded encouraging results. Noteworthy discoveries were made at False creek and near Moose Pass, not far from the Alaska Central Railway. Some very rich auriferous quartz has been found on Willow creek, an eastern tributary of the lower Susitna. Two small stamp mills were operated in this latter district during 1909.

The discovery of auriferous quartz in 1908 in the valley of Chatham

SILVER PRODUCTION OF THE WORLD.

Country.	1908. Oz. Fine.	1908. Kilograms.	1908. Value.	1909. Oz. Fine.	1909. Kilograms.	1909. Value.
North America:						
United States	(b) 52,440,800	1,630,909	$27,722,304	(b) 53,849,000	1,674,704	$27,733,312
Canada	(a) 22,106,233	687,504	11,686,239	(a) 27,878,590	867,024	14,358,310
Central America (b)	1,460,809	45,439	781,400	(e) 1,446,750	45,000	685,800
Mexico	(a) 72,597,304	2,258,081	35,429,291	(a) 72,653,534	2,259,830	34,439,809
South America:						
Argentina	(b) 127,108	3,954	68,000	(e) 128,600	4,000	60,960
Bolivia	(c) 6,027,060	187,442	2,941,204	(e) 7,000,000	217,700	3,317,748
Chile	(a) 1,685,785	52,435	553,063	1,423,698	44,283	379,271
Colombia	3,702,300	115,142	1,806,000	(e) 1,607,500	50,000	762,000
Ecuador	(b) 22,642	704	12,100	(e) 48,225	1,500	22,860
Peru	(a) 6,394,249	198,888	3,164,783	(e) 6,430,000	200,000	3,048,000
Europe:						
Austria	(a) 1,271,724	39,867	693,038	(e) 1,286,000	40,000	609,600
Hungary	(a) 405,476	12,612	226,464	(e) 405,090	12,600	192,024
France	(a) 1,957,066	61,184	1,322,553	(e) 1,929,000	60,000	914,400
Germany	(a) 13,080,998	407,185	7,068,362	(e) 12,860,000	400,000	6,096,000
Greece	(b) 829,025	25,786	443,400	(e) 803,750	25,000	381,000
Italy	666,984	20,746	347,910	(e) 665,505	20,700	315,468
Norway	(b) 226,175	7,035	121,000	(e) 225,050	7,000	106,680
Russia	(b) 132,122	4,109	70,700	(e) 131,815	4,100	62,484
Spain	(a) 4,175,674	129,881	2,444,114	(e) 4,501,000	140,000	2,133,600
Sweden	(a) 20,254	630	9,885	(e) 22,505	700	10,668
Turkey	(b) 7,971	248	4,300	(e) 48,225	1,500	22,860
United Kingdom	135,268	4,207	66,772	(e) 130,000	4,043	61,615
Asia:						
Dutch East Indies	(b) 510,070	15,865	272,800	(e) 514,400	16,000	243,840
Japan	3,960,327	123,166	2,175,555	(e) 4,200,000	130,620	1,990,649
Australasia	(a) 17,300,771	538,054	9,031,029	(a) 15,923,320	495,215	8,145,424
Africa	(b) 1,272,595	39,583	680,700	(e) 1,446,750	45,000	685,800
Other Countries	53,047	1,650	25,888	56,262	1,750	26,670
Total	212,569,837	6,612,304	$109,168,854	217,614,569	6,768,269	$106,806,852

(a) Official statistics of the country. (b) United States Mint Report. (c) Exports. (e) Estimated. The value of silver unless specifically reported in the official statistics of the country is taken as $0.488 in 1908 and $0.474 in 1909 (London quotations).

creek and in Skoogy gulch was followed in 1909 by similar discoveries at several other localities that apparently lie in the same belt. The country rock of this belt is chiefly quartz-mica and quartzite schist with granitic intrusives. During the summer of 1909 more or less systematic prospecting of quartz veins was carried on at 10 or more localities, most of them in a zone about 10 miles long, stretching northeastward from Pedro Dome and drained by creeks carrying auriferous gravels. Development work has been confined to surface prospecting, sinking on the veins to depths of less than 100 ft., and tunneling along them to distances not much exceeding 100 ft. The material has been milled in small lots by a small stamp mill established at Fairbanks during the winter of 1909. Much lode prospecting was done during the year in the Bonnifield district, which lies about 40 miles south of Fairbanks. Some promising prospects are said to occur in a belt that follows closely the base of the Alaska range. One very large ore body has been reported on Jerome creek, a tributary of Wood river. Systematic prospecting of this property is going on, with the use of a small stamp mill. Considerable quartz prospecting was also done in the Koyukuk and Chandlar regions.

Placer Mining.—The value of the placer gold produced in 1909 was over $16,000,000; that recovered in 1908 was worth $15,888,000. This is a remarkably good showing, for, owing to various causes, there was a falling off of nearly a million dollars in the gold output of Seward peninsula. This loss, however, was more than made up by the increased production of the Yukon camps, notably Fairbanks, Koyukuk, Innoko, Hot Springs, and Birch Creek. The installation of two additional dredges near Nome and the successful operation of three others in Seward peninsula and of three in the Fortymile district are the most significant facts in the placer operations. These dredges and the hydraulic plants operated in Birch creek, Hot Springs, Nizina, Porcupine, and other districts in Alaska indicate that, as bonanza mining decreases, progress is steadily being made in equipping plants to exploit the gravels carrying lower values.

At Nome, unfortunately, the installation of large plants has not gone on rapidly enough to insure the holding up of production when dry seasons curtail the output of the smaller operators. Except for the dredges and some small hydraulic plants there are but few large mining ventures in this field. Mining has also been retarded in Seward peninsula by lack of recognition of the comparatively small quantity of water available under head for mining purposes. This condition will have to be met before material advancement can be made in large mining enterprises. The summer of 1909 was one of the driest yet recorded in Seward peninsula.

Although there were no new developments in the Fairbanks district other than those in lode prospecting, already referred to, the gold production was larger than in 1908. The increase was due mainly to the output of a few rich claims on Engineer creek. Though the district is prosperous and many claims still contain valuable pay streaks, it must not be forgotten that on many of the creeks the days of bonanza mining are numbered. Unless means are at once devised for mining the very large bodies of auriferous gravels whose values are too low for exploitation by present methods, the output from the placers will soon decrease. During 1909 mining was continued on all the creeks that were productive in 1908. There was special activity along the lower courses of Cleary, Vault, and Dome creeks, and as a result a large amount of gold was taken out of the Chatanika flats. So far as known, Goldstream and its tributaries made the largest production, Dome creek standing second.

Of the districts adjacent to Fairbanks, Hot Springs and Birch creek were most prosperous, but mining was also done in the Rampart, Tenderfoot, and Salchaket regions. In the Hot Springs and Birch creek districts several large plants were operated during most of the season. In addition to the smaller mining enterprises three dredges were in operation in the Fortymile basin in 1909. One of these is on the south fork of Fortymile and two are on Walkers Fork. It is significant that dredges are successfully operated in this district—one of the most isolated placer districts in Alaska. The initial cost of these plants is probably double what it would be in some of the other districts, and, moreover, for two of these dredges the ground has to be thawed.

The Koyukuk district, which has been growing in importance as a gold producer, has been developed practically without the aid of outside capital. The productive placers of this district fall into three groups, (1) those of Myrtle, Marion, Missouri, and Gold creeks; (2) those of Vermont, Nolan, and Emma creeks; and (3) those of Mascot creek. Up to 1907, when the deep placers of Nolan creek were discovered, mining was confined to shallow deposits. In 1909 probably 90 per cent. of the gold was taken from the deep gravels of Nolan creek. The Koyukuk district is difficult of access and mining costs are high, but in spite of the adverse conditions the value of its gold output in 1909 was more than $500,000.

In 1909 the Innoko district produced gold to the value of $300,000. This indicates that systematic mining has begun. In midsummer placer gold was found on Otter creek, which flows into the Haiditarod, a northeastern tributary of the Innoko. So far as prospected the gold seems to be more uniformly distributed than in the Innoko gravels. A stampede to the Haiditarod took place from Fairbanks and other points in Alaska late in the summer of 1909. The fact that gold has been found also on the Toluksak, a tributary of the Kuskokwim, in what appears to be an extension of the same belt as that of the Innoko and Haiditarod, makes this general field attractive to the prospector.

Although the placer-gold output of the Yukon and Seward peninsula placers overshadows that of all the smaller districts, yet in 1909 these made an aggregate production of $500,000. Large hydraulic enterprises are established in the Porcupine district of southeastern Alaska, in the Nizina district of the Copper basin, and in the Sunrise district. Some progress was made in 1909 in preparing for larger plants in the Chistochina, Yentna, and Bonnifield districts. Many of these districts will become considerable producers of gold when railways and wagon roads have rendered them more accessible.

Arizona (By William P. Blake.)—Active development of the gold region of western Arizona continued during 1909 with most encouraging results, especially in Yuma and Mohave counties, where new properties have been opened. The existence of a gold-bearing region along the western border of the Territory is now recognized. This region is coincident with the uplift of the hydro-mica schists of the Arizonian, noted throughout the Territory as the country rock of valuable mineral deposits. It is of extreme antiquity, antedating in deposition the ancient sediments of the Silurian and Cambrian seas. These schists have a wide development west of the Harquahalla mountains, especially near Vicksburg, where they are traversed by many quartz veins.

The King of Arizona, in southern Yuma county, was worked without interruption, and added about $20,000 monthly to the gold output of the Territory. The North Star, now known as the Golden Star, maintained its prestige as a large producer. Prospecting and locating were actively prosecuted from Castle Dome on the south to Mohave county on the north. Mack's Ruby gold mine, about five miles above Parker, was bonded by Eastern men and is under exploration.

The gold mines of Mohave county were actively worked and were so well represented at the Territorial fair as to secure the medal for the best mining exhibit. The ores of the Gold Road mine were prominent. The Tom Reed mine, about 1½ miles south of the Gold Road, is in the same formation and has similar ore.

In Maricopa county, the old Vulture mine, near Wickenburg, operated successfully and shipped bullion after April. A new mill of 100 stamps is planned. Five bulletins of progress were issued during 1909, showing active sinking and driving and the development of reserves. In Pinal county work upon the Mohawk, near the Mammoth, at Shultz, continued as in 1908 under the direction of Mr. Roberts.

In Graham county the Crawford mines, north of Clifton and Morenci, were under active development and a small cyanide plant was operated with a reported extraction of 85 per cent. A new property, called the Gold Belt, was opened near Morenci and a 10-stamp mill was erected.

An accident in June caused the stoppage of the pumps on the 1000-ft. level of the pump shaft of the Tombstone Consolidated Mines Company, and the mines were speedily flooded. The water rose rapidly to the 800-ft. level. A new set of pumps equal in capacity to those drowned were installed on the 800, and when the 1000-ft. level is unwatered and the pumps are recovered, the maximum total pump capacity will be about 12,000,000 gal. daily, or 8500 per min. The day before the accident the quantity of water pumped was 6,706,080 gallons. Shipments of ore and concentrates were continued from the 700- and 800-ft. levels. The exploration of the ground below the old water level fully confirmed the expectations formed of the geologic conditions and mineralization of the lode below the permanent water level. Neither the grade nor character of the ore was affected by the water.

California.—The gold output of California can be counted on as $18,000,000 to $21,000,000 annually, the only variation depending on the amount of rainfall. With a small precipitation the gravel mines have short seasons for washing and some of the mills of the quartz mines have to stop work for lack of power. Large numbers of the quartz mines of the State are now run by electric power, generated by water, so that when water supply is short the electric current cannot be supplied in sufficient quantity. Some of the larger properties are now equipped with auxiliary steam power plants, ready for use in case the water or electric power plants fail. Again, heavy floods affect the dredging industry, as in 1907, when a number of dredges at Oroville were wrecked. The quartz mines are yielding more gold than the placers, as has been the case for many years, but the quartz mines are not increasing their yield as the placer mines are, and before long it is expected that the placer yield will exceed that from quartz mining operations.

The total gold yield for California for 1908 was $19,329,700, and the silver 1,703,800 fine oz. The gold yield of 1909 has been estimated by the U. S. Mint at $21,271,300, and the silver at 1,705,200 fine oz.

No special activities were shown in quartz mining in 1909, except in the county of Sierra, where discoveries of very rich ore were made in reopened mines. The finding of "candlebox" ore in one mine led to the development of several others, long idle. In other districts there were few changes of conditions to be noted. The Grass Valley district of Nevada county, continues to be the leading quartz-mining section of the State. None of the other counties, even those of the Mother lode, approach it in production of gold. The deep mines of the State are yielding annually about 2,500,000 tons of ore, of which 2,000,000 tons are milling ore, averaging from $5 to $5.75 per ton. The rest is copper ore, which is treated at smelteries. This carries gold and silver, and, in fact, by far the largest proportion of the silver is derived from the treatment of copper ore. The need of silicious ores for flux with the copper ores in late years has had a marked effect on gold mining; many mines can now be profitably worked without reduction works, because of the ready sale for the quartz. This is especially the case in Shasta county, where the largest smelting plants for copper ore are in operation.

The quartz mines of California are now producing annually a few million dollars more than the combined forms of placer mining, which include dredge, hydraulic, drift, river-bar, ocean beach and surface placers. The dredges are now yielding about 80 per cent. of the placer gold output. Dredge mining is now the most progressive of the different forms of gold mining carried on in California. With about 75 dredges at work the annual gold yield from that source is between $7,000,000 and $7,500,000. When this form of mining was begun at Oroville in 1898 the yield for the year was only about $19,000. Since then over $31,000-000 has been produced by dredging operations, and the business is increasing yearly. The latest machines are very costly and heavy, and are capable of handling over 280,000 cu.yd. of material monthly. Some of the machines are doing the work at an operating cost of less than 2c. per cu.yd. Dredging mining is now being carried on in 10 counties of California, the largest operations being in Butte, Yuba and Sacramento counties. A few dredges are working in Calaveras, Siskiyou, Trinity, Shasta, Merced and Stanislaus counties, and new dredging grounds are being prospected in many places. Larger machines are taking place of lighter and smaller ones in the older dredging fields.

Hydraulic mining is in a decadent stage, the total yield from this source being less than a million dollars annually. The most prosperous counties for this form of mining are Siskiyou and Trinity. Drift mining also is showing a lessened yield, though there are signs of revival in drift work, especially in the upper mountain counties of Sierra and Plumas, where a number of old drift properties have lately been reopened and some new ones started. The partial cessation of hydraulic mining in the mountain and foothill central counties has cleared the streams of débris, so that placer mining on the surface and in the river bars has been more prosperous than for a long time. The mountain streams have been mined lately on old bars. Mining the sands of the ocean beaches has not been carried on to any great extent for the last few years.

The mines in the Mother Lode counties of Amador, Calaveras, El Dorado, Mariposa and Tuolumne still continue to furnish three-fourths of the milling ores of the State, though the average recovery per ton is much less than in the other counties where the veins are smaller and richer. The average recovery is less than $4 per ton when all the counties in the Mother Lode are considered. In Nevada county, where the most productive quartz mines of the State are being worked, the average value recovered per ton is considerably over $10 in gold and silver. Some of the gold mines in Amador county, on the Mother Lode, are now being worked to a vertical depth of 3400 ft. and at that depth are taking out as good ore as they ever had near the surface. This has encouraged men working other deep mines, and explorations are now being made deeper than ever before. Shafts 1000, 1500, and even 2000 ft. deep are being sunk without stopping to drift, so as to open properties in a suitable manner.

The North Star Mines Company, Grass Valley, Cal., in 1909 milled 91,610 tons of ore which yielded $13.59 per ton at a cost of $5.232 per ton for current operation and $1.189 per ton for development, a total operating cost of $6.421 per ton compared with $6.556 in 1908. The entire production came from the North Star mine. The upper or old workings of the North Star mine, on and above the 2700-ft. level, produced 21,819 tons of ore which yielded $14.39 per ton. The deep workings produced 69,791 tons, yielding $13.34 per ton. The upper levels contain an ore supply of about 25,000 tons, and the lower levels are stated to have several years' output developed. Exploration at depth has been discontinued for the present on account of the large reserve of ore already available.

Colorado (By George E. Collins).—The mining industry in Colorado was fairly prosperous in 1909, but there were no very important new developments. The production of gold was slightly, and that of silver considerably less, than in 1908, while that of the base metals showed a decided improvement.

No review of conditions would be complete without mention of the passing of the Argo smeltery, which for a generation was the main outlet for the ores and concentrates of the northern counties. A new smeltery of the semi-pyritic type was built close by, and is now being operated by the Modern Smelting and Refining Company; the Carpenter plant at Golden is being overhauled, with a view to the resumption of operation. The American Smelting and Refining Company's plant at Durango was hard hit by the railroad washouts near Silverton and Telluride, from which its ore supplies are derived. The Globe smeltery at Denver was only partly supplied with ore from this State. What we really need is new mines and new mining districts, but unfortunately there is little chance of finding either without more energetic prospecting than has been done for some years past.

A project which, if successful, may be of great importance, is an experimental mill now being erected at Georgetown for the treatment of mixed lead-zinc-copper sulphide ores, bearing precious metals. The treatment is to be by dry chlorination and solution of the chlorides in water, followed by successive precipitation of the metals, and electrolysis of the remaining zinc chloride, somewhat on the lines of the Swinburne-Ashcroft process, tried several years ago in England. The occurrences of such ores in the State, especially in central Colorado, and in the San Juan district, are numerous, and should some such method prove economically successful it may eventually be of great value to the mines of this State.

Cripple Creek.—Shipments were large, and on the whole the year was a satisfactory one. The relative importance of the Portland lessened, and will doubtless continue to do so; but the Elkton, Vindicator, Golden Cycle, Strong, Granite, El Paso, Cresson and Mary McKinney kept up a large output. It is probable that the present production of the camp will be maintained for some years to come. No sensational new discoveries were reported. The new mill at Stratton's Independence began treating 250 tons of dump material daily by concentration and raw cyaniding, at a profit of probably 75c. per ton. The roasting mill designed by Philip Argall to treat the regular mine ore is not in operation. The Portland company is building a mill designed to treat the low-grade ores by a modification of the cyanide process.

The Roosevelt drainage tunnel was driven a total distance of 12,000 ft. from the entrance, and is within a comparatively short distance from the contact of the granite and the fissured volcanic rocks in which most of the veins occur. During the year remarkably rapid progress was made in extending the tunnel. It will probably begin draining some of the deep mines next year.

Gilpin and Clear Creek Counties.—The output was about the same as that of 1908. In Gilpin county the deep Nevadaville mines are still submerged awaiting drainage by the Argo (Newhouse) tunnel, which advanced at an average rate of 300 ft. monthly. The actual drainage of the district will, however, in all probability proceed more slowly than at Cripple Creek. None of the larger mines were especially prosperous. The greatest producer was probably the Fifty company, which maintained a large output from the Bobtail vein. The Saratoga is now in condition for active work through the Newhouse tunnel. The Topeka was unwatered and commenced production.

At Idaho Springs the Sun & Moon, which was operated in 1908 under lease, was at first unsuccessful, but work was later resumed by local operators who opened up a body of ore of good shipping grade. The Gem and Lamartine were worked on the tribute system, but the output was less than in recent years. The Stanley, also under lease, is being unwatered.

At Georgetown the Capital tunnel was the largest producer. Connection was made from the Burleigh tunnel to the Seven Thirty, which was drained and opened for work. In the Argentine district the Santiago and Waldorf properties opened up important bodies of ore; the grade, however, is rather low, and the expense of working higher than in the more accessible camps.

San Juan District.—The production of the Camp Bird mine, near Ouray, was greater than ever and the proportion of net profit remarkably high. A considerable output was maintained by lessees from the Revenue group, but in other respects mining in Ouray county was inactive.

San Juan county had a poor year, owing partly to another fire at the Gold King, which caused a suspension of work at that property for a great part of the year, and partly to a succession of washouts on the railway which prevented all shipments throughout the summer. The camp is again busy, the Gold King, Sunnyside, and Hercules being the principal producers. The Iowa-Tiger was worked by a local leasing syndicate with very profitable results. The ore of this mine is largely galena, containing gold and silver. The Silver Lake mines, carrying gold, silver, lead and copper, were operated entirely by tributors, some of whom have done well. The Gold Prince, formerly known as the Sunnyside Extension, was operated by a receiver appointed by the court.

At Telluride the three great mines are the Smuggler-Union, Liberty Bell and Tomboy, which jointly produced nearly all the output, with some assistance from the Alta and a few smaller properties. The Smuggler opened up ore in the tenth level, which will enable it to maintain its output for several years more. The Liberty Bell exposed a large tonnage above the Stilwell tunnel, which insures a long life. The grade of the ore in the Argentine vein of the Tomboy company decreased considerably in depth, but thanks to a large tonnage and cheaper mining costs, it was still profitable.

Other Districts.—At Leadville, the Ibex group maintained a large output, mined principally by leasers. The New Monarch mine is shipping about 1500 tons monthly to the Salida smeltery.

In Summit county dredging was extended by the construction of two heavy dredges on the Blue river, and a second boat was placed in operation in French gulch. The latter is reported to have done especially well. It does not, however, seem probable that dredging will extend to the other districts in Colorado, or that it will become relatively important.

At Aspen an important discovery of ore was made in the Smuggler property, to facilitate the working of which the Free Silver shaft is to be unwatered, and deepened. An addition is being made to the electric power plant of the Roaring Fork Company in order to furnish the additional power that will be required for this work. The output showed a notable increase during the last two or three months, and a further increase is probable.

Idaho (By F. C. Moore).—Idaho produced 67,214 oz., or $1,389,300 of gold during 1909. The Silver City district ranks first in production with $404,983; Boise Basin second with $241,277 and Elmore county third with $209,106. The greater portion of the production of this county was derived from the quartz mining operations in the Atlanta district. Custer county ranks fourth in gold production with $101,901 to its credit.

Dredging operations which are contemplated for the future will undoubtedly increase the gold production of the State in years to come. The successful operation of a number of dredges, which have been working during the last few years, has increased interest in the opening up of large deposits of dredgeable ground in various sections of the State.

Every mining county in the State produced more or less silver, the bulk of which was derived from the Cœur d'Alene galena ore, which produced 88 per cent. of the total production of the State, 7,054,500 oz., with a market value of $3,633,209. The next in importance in the production of silver was the Silver City district in Owyhee county, which produced between 9 and 10 per cent. of the State's total production. Many properties in several sections of the State, with a large tonnage of dry silver ores in sight, are lying inactive owing to the lack of metallurgical processes and transportation facilities.

Montana. (By W. P. Cary).—The receipts of the United States Assay Office, at Helena, show that the precious-metal output of the State increased materially during 1909. In Silver Bow county, the British-Butte company started to operate its gold dredge in January and continued operations until November. The title to the company's ground was in litigation during the year and has not yet been finally determined.

In Broadwater county the Keating Gold Mining Company and the Ohio-Keating company showed the best results. The Keating produced steadily at between 50 and 100 tons daily. The Ohio-Keating was not formed until May, but since that time sank its shaft an additional 100 ft., and shipped during October, November and December.

In Fergus county the Barnes-King, Cumberland and Kendall properties were operated. The Barnes-King and Cumberland made a number of shipments. In Madison county the Conrey Placer company had three gold dredges in operation throughout the year. The McKee group and the Pioneer company also carried on operations. In Granite county the Bimetallic mine continued to operate throughout the year and a new cyanide plant was installed.

It will be recalled that the enormous silver production of Montana comes from the copper mines at Butte, the operations of which are detailed in the article on Copper, elsewhere in this volume.

Nevada.—More than 286 producing mines and more than 400 others are operating in the State. The financial depression of 1907-08, following a phenomenal activity in mining and prospecting, caused the suspension of hundreds of operations. During 1909, some of the most likely of these operations resumed and some new exploration work was undertaken, particularly in the northern counties. The industry has now largely passed back to the hands of actual miners and is not dominated by speculators, as in the boom days following 1902. Attention was given during 1909 to the opening up of the old camps in Eureka county, and the revival of the Comstock, after more than 20 years of sleep, is assured. In fact, real mining is going on in nearly every camp, and the general results accomplished are most important for the future of the industry. Many new treatment plants were completed or begun during the year, and the railroad situation was improved by extensions and by reduction of rates.

The Comstock.—The task of unwatering the Comstock mines, which has been under way since 1898, was characterized by more definiteness and energy in 1909 than heretofore, with resulting good success. Under the contract with the Comstock Pumping Association the tunnel company has expended nearly $335,000 for new timbering, railroad track, drain flume and complete repairs. The tunnel drains and ventilates all the mines at a depth below their respective collars of 1650 to 2000 ft., and is essential in the operation of the properties.

The output from the deep levels of the Ophir, since the drainage began, amounts to $1,700,000; the output in November, 1909, was $50,000, and this was maintained throughout the year. The Mexican mine opened a new ore body at the 2300 or deepest level, which is now being prospected. The Consolidated Virginia began sinking as soon as the drain flume in the tunnel was completed and has now reached the 2800 level. The Ward shaft has equipment to reach the 3100 level, and is now down 2575 ft. The Alta shaft will be used for deep drainage in the Gold Hill mine.

The Yellow Jacket, Crown Point and Belcher are all producing low-grade ore which was not formerly economical. This ore is being milled in the new Yellow Jacket concentrating mill, which has a capacity of 6000 tons per month and is reported to be making a saving of from 83 to 89 per cent., yielding a concentrate valued at $150 to $250 per ton. The Butters plant is handling low-grade ore from the surface workings of the Chollar and Potosi, and high-grade ore from the lower levels of the Ophir and Consolidated Virginia. The Comstock company's mill at the mouth of the tunnel is now in operation, treating ore from the Savage mine, which is delivered through the tunnel. As an indication of the ores which are expected in the deep levels the following report for a December week from the Ophir mine is of interest: On the 2000 level, 37 cars assaying $65 per ton; on the 2200 level, 80 cars assaying $39.34 per ton; on the 2300 level stopes, 303 cars assaying $38.32 per ton; on the 2300 level drift, 65 cars assaying $58.33 per ton.

It has been demonstrated that the ores of the Comstock are easily concentrated and that the tailings can be successfully cyanided. Nine reduction plants are at work on or near the Comstock lode at present. These include the Butters, the Yellow Jacket, the Comstock Tunnel Company's, the Dietrich, the Rocky Point, the Overland, the McTeague, the Davis and the Pfeffer mill. The plants are all small, except the Butters plant and the Yellow Jacket mill.

The district is now supplied with cheap electric power, costing from $4.50 to $6 per h.p. per month, according to the amount consumed.

Goldfield.—In comparison with the feverish activity of a few years ago, the Goldfield camp was very quiet during 1909. Yet during that year the camp produced more gold than ever before. In July, 18 mines, employing 677 men, and a like number of leases, employing 116 men, were in operation. Of the men employed by mining companies, nearly 75 per cent. were on the payrolls of the Goldfield Consolidated.

The Goldfield Consolidated Mines Company, during the calendar year 1909, distributed dividends amounting to $1.40 per share, or about $5,000,000 on the 3,558,848 shares outstanding. The company produced 194,480 tons of ore of an average gross value of $37.98 per ton, from which a recovery of 92.5 per cent. was realized. The operating cost for the year was $6.77 per ton mined. The cost for the last 10 months, during which the Consolidated 100-stamp mill was operating, was $6.34, or 43c. per ton less than the average for the year. However, only $1.56 was charged to development during that period, as compared with $1.94 for the entire year. The total cost per ton, including the above, concentrate treatment, plant operation, taxes and all other expenses, was $8.08 per ton. The Goldfield Consolidated Mines Company now owns in fee all the property (380 acres) of the Mohawk, Red Top, Jumbo, Laguna and Goldfield Mining companies.

GOLDFIELD CONSOLIDATED MINES COMPANY.
OPERATING COSTS FOR 10 MONTHS ENDED OCT. 31, 1909.

	Labor.	Supplies.	Power.	Department.	Construction.	General.	Total.
Stoping	$1.24	$0.66	$0.03	$0.25	$0.02	$0.18	$2.38
Development	0.80	0.36	0.02	0.20	0.08	0.10	1.56
Milling	0.71	1.10	0.36	0.09	....	0.04	2.30
Transportation	0.063	0.029	....	0.008	....	....	0.10
Total	$2.81	$2.15	$0.41	$0.55	$0.10	$0.32	$6.34

The management seems to be able to produce ore of almost any desired richness. The manager estimates the profitable ore now exposed at 800,000 tons, sufficient to supply the Consolidated mill at the rate of 850 tons per day for nearly three years. The Consolidated 100-stamp mill was completed in December, 1908, and the concentrate plant two months later. That gave facilities for 700 tons of ore per day. In September, 1909, the Hampton stope caved and wrecked the 90-ton Combination mill. At that time it was decided to increase the capacity of the Consolidated mill to 850 tons, and this addition began work in January, 1910. The new installation included six 6-ft. chilean mills as regrinders between stamps and tube mills, 24 Deister concentrators, two agitators and an air compressor. It cost about $60,000. Other installations included a 150-h.p. air hoist at the Clermont shaft together with buildings and bins for a 600-ton daily production, safety devices on the large hoists, and a 30,000-gal. tank for fire protection. A fire in the refining department on April 7, 1910, threatened the entire mill, but was controlled before heavy damage had been done. The necessary repairs were quickly made and operations were resumed shortly.

The 100-stamp mill was operated steadily after Dec. 26, 1908, and a continued improvement was made in tonnage, extraction and costs. In October an average of 649 tons per day was milled at a cost of $1.915 per ton, with an extraction of 94.49 per cent. The concentrate-treatment plant began running in March. Its extraction, added to the smelting recovery from residues carrying over $20 per ton, equalled the extraction from untreated concentrates which would have been paid for by the smelters, and the saving in cost was $25 per ton of concentrates. Residues below $20 are stored on a dump for future treatment. The primary and secondary amalgamation plates were abandoned, the free gold being allowed to go into the concentrates. Two plates are installed over which the concentrates pass before entering the concentrate-treatment plant, and all the gold which is too coarse to pass readily into solution is amalgamated. The 24 small classifiers below the batteries were replaced by two 8-ft. cones with good results.

Developments extended the productive area laterally and downward. Two new bonanzas, the Hampton and Clermont 750, are as rich as any of the older bonanzas. Ore was discovered in the latite, where it was previously thought unlikely that ore bodies existed, at a depth of 1500 ft. along the dip of the vein. The change from dacite to latite did not lessen the size, continuity or value of the ore bodies.

Esmeralda County.—In the Silver Peak district the Pittsburg-Silver Peak Gold Mining Company completed its new mill, which has an approximate capacity of 12,000 tons per month. Other properties in this district are the Silver Peak-Valcalda, in which the Newhouse interests have acquired control, and the Goldfield-Silver Peak property on which a 10-stamp mill is being installed. Exploration and development were carried on extensively in the Lida district, 32 miles from Goldfield. On the Monarch a silver-lead strike was made. The Nevada Exploration Company carried on exploration on the Wisconsin group. Nevada-Florida installed a 10-stamp mill. The Washington-Nevada sunk 500 ft. in development of a property. The Indian Spring company installed equipment and is developing. The old Centennial is being explored, and the Death Valley mine, east of Lida, now known as the Red Wing, has developed high-grade silver-lead ore. In the Hawthorne district the Lucky Boy is reported as having been sold to the United States Smelting, Refining and Mining Company.

Nye County.—The Tonopah mine claims to be the greatest silver-producing mine in the United States, and it is asserted that its dividends for the last three years have been greater than that of any other silver producer in the world. Montana-Tonopah operated its mine and mill successfully and efficiently, and the discovery of new orebodies in the property was reported. The West End Consolidated Company developed a large tonnage of second-grade ore and continued shipments of high-grade. The MacNamara carried on development work, blocking out milling ore. Numerous leases operated successfully in the district. Belmont, Midway and Tonopah Extension all continued to be active producers.

Bullfrog was generally inactive. The principal mine, the Montgomery-Shoshone, made a successful showing during the first six months of the year, treating about 6000 tons per month from the 200 and 300 levels. During the last half of the year the net production of the mine decreased considerably. The Montgomery Mountain Company is exploring the South-Rhyolite contact, adjoining the Montgomery-Shoshone properties. Owing to the lack of milling facilities much of the low-grade ore in the district is at present not available.

New Mexico (By R. V. Smith).—The gold produced in 1909 came mainly from placers and from the mixed ores of copper, lead or silver and zinc, of the central and southern counties. By far the most productive areas were those reached from Silver City, in the southwestern part of the Territory. Placer mining in Colfax county, which was formerly the most active section, was largely suspended during 1909.

Lode mining in the north-central counties increased and development was pushed at San Pedro, Cerrillos, Madrid and all the gold camps.

Some of the mines shipped to Pueblo, Colo., including the Ajax and the Pay Ore group, both new mines. Extensive cyanide tests are being conducted on the gold ores of this section, but no installations were made in 1909. A rich strike of tellurides in the White mountains caused a rush of prospectors to the section. At Parsons the 200-ton cyanide mill was idle pending a reorganization of the company. Mining in the Black range was conducted at seven camps. The principal mines added to their equipment, increased shipments and continued to operate their mills. The erection of one mill was begun. Development in this region is rapidly bringing it to the front as a producer of high-grade ores, some shipments showing as high as 20 oz. gold per ton. The low-grade ores are being stocked for cyanide treatment later on.

In Socorro county four cyanide mills were operated, one at Rosedale, and three in the Mogollon mountains. A modern cyanide mill of 150 tons' capacity was built by the Socorro Mines Company. Crushing with stamps and tube mills in cyanide solution with pressure filtration in Burt filters and zinc shavings precipitation is practised. Dorr classifiers are used, also Brown-Pachuca tanks for agitation with compressed air. The mill was completed in the latter part of 1909. The mill at the Cooney mine, across the range, was run for a short time.

In Grant county gold was obtained from the Pinos Altos and other placers in the vicinity of Silver City and Hachita, from the mixed gold-copper ores of Lordsburg, Steins Peak, Central, etc., and from the gold-silver-lead ores of Sylvanite, Steeplerock, and other districts. The camps near Lordsburg, which is the junction point of the Southern Pacific and the Arizona & New Mexico railways, shipped about 40 cars per month throughout the year. The shippers received a premium for the ores in most cases on account of their desirable character for use as converter linings.

Silver forms about half the bullion value at Mogollon and Rosedale, and is an important constituent of the ores in Grant, Socorro and Luna counties. Steeplerock, Granite Cap, Pyramid, Hermosa, and the camps in the central part of the Territory were all more actively developed than during 1908. The experimental mill at Lake Valley, on the Monarch mine, wherein it was intended to separate silver and lead from zinc, was not successful on account of lack of water.

South Dakota (By J. V. N. Dorr).—The year 1909 was not very prosperous for mining in South Dakota and its close was overshadowed by the shutdown of the Homestake mines and mills to avoid a strike. The Homestake company has always maintained the best relations with its employees and has had the unique record of operating 31 years without a strike.

The union started an active campaign in the summer of 1909 to increase its membership. The company filed suit in the United States court against the union for $10,000 damages alleged to have been sustained on account of the intimidation of the men, and on Nov. 17 published notices that after Jan. 1, 1910, no union men would be employed on the property and that all employees desiring to work after that time must register before Dec. 15. On Nov. 23, the company, finding that the union had decided to call out its men on Nov. 25, shut down the property with the exception of work on the waterpower plant. Applications came in rapidly and enough men were available to operate part of the property early in 1910. It is not expected that any violence will occur, as the company is prepared for an emergency and the leaders of the union are strongly against any disturbance.

The Homestake started up gradually the latter part of January, 1910, on a non-union basis and by March 5 the mill was dropping all its stamps and had a full crew of men. The company has resumed dividends again at the regular rate, so that the trouble may be considered entirely over. It is interesting to note the placing of a camp, containing between two and three thousand union men, on a non-union basis in such a short time with so little friction. The other companies operating in the Northern Hills concluded that with one mine employing three-fourths of the men in the district as non-union labor, it would be better to have it all that way. They shut down early in January and announced that when they started again it would be on a non-union basis. The Mogul and Golden Reward companies have just started and it appears now as if the whole Black Hills will be operating within a month on a non-union basis It is reported that the Homestake company has found that, even with a large crew of green men, their labor cost is slightly cheaper than before they shut down; they have also secured a very good class of men, with a much larger percentage of Americans than were in the mine before.

The Homestake company finished the addition to its slime plant during 1909 and began the construction of a hydraulic power plant in Spearfish cañon. The installation includes several miles of tunnels and is expected to furnish from 3000 to 4000 h.p. at the mills at a cost of at least $1,000,000 for the plant. The saving in operation will more than pay interest on the money expended, and it is expected that the plant will be running by the end of 1910.

There were no new developments in this district during 1909. At its close the only fine-crushing mills operating at full capacity were the Mogul, handling about 350 tons; the Golden Reward, 200 tons, and

Lundberg, Dorr & Wilson, 100 tons. The Imperial company, while still prospecting for ore on the lower contact in the Portland district, is running one shift and treating about 40 tons. It is, perhaps, of metallurgical interest to note that the first three mills above mentioned are all grinding the ore with chile mills and are using the Moore process for treating the slimes, whereas several years ago stamping and decantation were in general use. The recent purchase of adjoining property by the Wasp No. 2 will give renewed life to that remarkable concern, which is now handling about 200 tons of ore in two eight-hour shifts.

The Golden Crest company completed its 200-ton mill during the summer, but did not start it as the company was engaged in enlarging and deepening the shaft. The Branch Mint company is shut down. The Gilt Edge Maid mine is shut down, but negotiations are under way to secure capital for operating it on the large scale required to make it yield a profit.

Utah (By P. E. Barbour).—Mercur is still Utah's greatest gold camp and in the last seven years has produced 56 per cent. of the gold produced by the State. The Consolidated Mercur, at whose Golden Gate mill the cyanide process was first tried on an extensive scale in this country, has produced over $14,000,000 and has paid in dividends over $4,000,000. In 1909 it mined and milled approximately 750 tons of ore per day. The Mercur ores are complex, classified as oxidized and base; the base ores require roasting before cyaniding. This costs $1.05 per ton of ore roasted. The total average cost of mining for 1909 was $1.53 and for milling $1.09, making a total cost of $2.62. The mill heads averaged $3.58 and the tailings 88c. per ton. The cyanide consumption amounted to 0.78 lb. and the zinc consumption to 0.36 lb. per ton of ore. Nearly 300,000 tons were mined and milled during the year. The Boston-Sunshine company remodeled the Sunshine mill and for several months treated 125 tons of ore per day. The payment of dividends was begun. The mill heads averaged $3.50 and the tails 35c. per ton. The milling costs were 88c. per ton. The consumption of cyanide and zinc was 0.76 and 0.45 lb. respectively. The Daisy mines were purchased by a close corporation and the old mill which was used for the Sacramento dump ore was acquired and remodeled. The West Dip installed equipment, remodeled its mill and repaired its six-mile pipe line from Ophir. When these two mills are in full operation Mercur will be mining and milling 1200 tons of ore per day.

Tintic during 1909 maintained its leadership in the number of individual shippers and dividend payers. The deeper workings of the camp promise as bright a future as the past has been. The Eagle & Blue

Bell shaft was sunk below the 1000-ft. level, the Grand Central was working on the 2200, the Centennial-Eureka on the 2260, the Lower Mammoth on the 2200, the Mammoth on the 2100, and in each case the lower workings were as good or more promising than the upper levels. Some new shippers entered the list and several old-time shippers resumed. The introduction of churn and diamond drills for prospecting was an innovation in Tintic.

Of most import to Beaver county was the reorganization of the Newhouse Mines and Smelters under the new name of the South Utah Mines and Smelters. Before the closing of these properties the output amounted to more than 500,000 lb. of copper per month. The new Cactus mill has a capacity of 1200 tons per day. The mine is opened to a depth of 1000 ft. The reorganized Majestic Mines Company reopened the Harrington mine with new machinery and pumping equipment. The new shaft encountered a body of silver-lead ore which varied from 8 to 15 ft. in width and on the 500 level was 120 ft. long. The Red Warrior did several thousand feet of development and developed a body of sand carbonates of large proportions. Sixty-five carloads of ore netted the company $55,000. The Cedar-Talisman after the consolidation confined its work to the lead-silver ores of the Cedar.

The Sevier Consolidated resumed work at Kimberley. Both mine and mill are equipped with complete and modern electrical machinery. Electricity is supplied by the company's power house in Clear Creek cañon. The Gold Development Company, at Marysvale began to reopen its mines in preparation for a 300-ton mill and tram.

The Philippines (By H. G. Ferguson).—In two of the three principal districts mining companies have successfully passed through the development stage and are now preparing to pay dividends. Everywhere development work is being carried on and, owing to the courage of the first pioneers, capital has begun to flow a little more freely. Of the three stamp mills in the Masbate district one five-stamp mill was found to have been poorly designed and it was dismantled. Neither of the two 10-stamp mills was in operation during 1908. In lode mining continued development work is showing up large and easily worked ore bodies. The ore as a rule is not of high grade. The chief development work in 1908 was done by the Keystone Mining Company on Aroroy mountain. The Colorado and Eastern mining companies did considerable development work with satisfactory results. Both companies expected to go ahead on a much larger scale during 1909.

Less has been done under the American régime in respect to lode mining in the Paracale district than might have been expected. This delay is due in great measure to the early confusion in regard to titles. The two principal mines of the district, the San Mauricio and the Tumbaga, both of which were formerly the property of the Philippine Mineral Syndicate, have been taken over by American capital. At the San Mauricio mine the old workings have been retimbered, sinking has begun and a 20-stamp mill has been brought out. On the Tumbaga property the old workings have been unwatered and preparations made to continue sinking the shafts.

The Baguio district is the principal mining region of the islands, and during 1908 work has gone steadily forward. The Consolidated Mining Company possesses a six-stamp Hendy mill, a fairly modern cyanide plant and a classifier and Wilfly table. The Bua Mining Company has over 600 m. of drifts and 150 m. of cross-cuts; 1500 cu.m. of ore have been removed by stopes. The ore is treated in a Hendy six-stamp mill and a cyanide plant, similar to that of the Consolidated Mining Company.

The plains of the Paracale and Malagit rivers afford very promising dredging ground, which is now being thoroughly prospected. The Paracale Dredging Company has had a dredge in operation on its property near the town of Paracale, and such excellent results have been obtained that several other dredges will be in operation in a short time on neighboring properties. The placer ground in the vicinity of Paracale generally consists of four to five meters of barren clay mixed with vegetable matter. In places this overlies a few centimeters of coral, and below this is a varying amount of gray clay carrying gold. Beneath this again is an irregular amount of rich sand and quartz pebbles, the latter often showing large amounts of free gold. The gold brought up by the dredge now working is remarkably angular and often shows distinct crystalline structure. The quartz pebbles are often sharp and angular, showing that they have traveled but a very short distance. The bed-rock appears to be a schistose rock, decomposed to a clay, which is easily cut by the dredge buckets, making it possible to secure practically all of this rich gravel.

The dredge at present in operation is of the New Zealand type; it has no stacking ladder and no quicksilver is used in the riffles. During a period from May 25 to Dec. 31, 1908, 50,244 cu. yd. were handled and 2814 oz. of gold, having a value of $50,654, recovered.

Two more dredges are now (March, 1909) in course of construction. One of these was formerly in operation on the Guinobatan river in Masbate, and has been transferred to Paracale, where it is being rebuilt. The other is of the New Zealand type, both screen and stacking ladder being dispensed with, and all material falling directly from the tumbler to the tables. In March, 1909, the pontoon for this dredge was almost completed. The dredge now in operation has 38 buckets of 137 liters capacity besides three grab hooks. The dredge from Masbate, 45 buckets of 102 liters capacity each, and the third dredge, under construction, 43 buckets of 142 liters capacity.

Gold and Silver Mining in Foreign Countries.

Australasia (By F. S. Mance).—The yield from the gold mines of Australasia in 1909 was lower than in any recent year, and, judging by existing conditions, there seems little prospect of better results during 1910. The production of silver and lead suffered by the closing down of several of the mines at Broken Hill, owing to industrial troubles, and was less than for many years past. Gold mining, as a whole, made no headway during the year. The output was mainly contributed by the established mines, and the yields have diminished in value with depth.

PRODUCTION OF GOLD IN AUSTRALASIA.
(In fine ounces.)

State.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Western Australia	1,819,308	2,064,801	1,983,230	1,955,316	1,794,547	1,697,554	1,647,911	1,595,263
Eastern States:								
Victoria	720,866	767,351	765,596	747,166	772,290	695,576	670,910	654,222
Queensland	640,463	668,546	639,151	592,620	544,636	465,882	465,085	455,577
New South Wales	254,435	254,260	269,817	274,267	253,987	247,363	224,792	204,709
Tasmania	70,996	59,891	65,821	73,541	60,023	65,355	57,085	44,777
South Australia (a)	24,082	21,195	29,177	20,330	24,439	10,651	9,162	(e) 7,500
Total Commonwealth	3,530,150	3,836,044	3,752,792	3,663,240	3,449,922	3,182,381	3,074,945	2,962,048
New Zealand	458,993	479,715	467,898	492,954	534,616	477,312	471,967	485,179
Total Australasia	3,989,083	4,315,759	4,220,690	4,156,194	3,984,538	3,659,693	3,546,912	3,447,227

(a) Northern Territory is included with South Australia. (e) Estimated.

The comparative statement shows that Western Australia is still the largest contributor, having furnished 46 per cent. of the total yield for 1909. Gold mining now seems to have reached a normal level in this State, and the present rate of output should be maintained for some years to come. Efforts directed toward reducing mining and milling costs, and securing a higher extraction were attended with satisfactory results, and ores at one time regarded as valueless are now made to yield profitable returns. In addition the developments at depth in the mines on the Boulder belt are such as to afford satisfaction. In the Great Boulder Proprietary the workings have attained a depth of 2500 ft., and the lode where located by means of a bore at a depth of 2400 ft. was proved to be 14 ft. wide, and for a width of 3 ft. it assayed 22 dwt. per ton. Borings conducted at deeper levels gave even better returns. The main shaft in the Golden Horseshoe is over 1800 ft. deep, and the lode at the bottom level was proved for a width of 12 ft., and assayed 9 dwt. of gold per ton. The Ivanhoe main shaft is being carried down to 2270 ft., and at the 1820-ft. level the Ivanhoe-East lode was driven along for a length of 400 ft. or more, and proved to have a value of over $12 per ton. It will thus be seen that these mines possess extensive ore reserves. The sound position of these old established mines is enhanced by the fact that several discoveries of importance have been made, work recently undertaken having proved an extension of the payable auriferous area both to the north and south.

The East Murchison field includes several promising sections which are rapidly coming to the front. Among these are the Wiluna and Black Range districts, and the former, though somewhat remote from railway communication, should with its extremely large soft lodes become in time a prominent producing center. The principal mines in this area are the Black Range gold mine, Oroya-Black Range, and the Sandstone Development Company's leases. The output of the old field of Yilgarn is on the increase.

The Southern Cross district, which was completely overshadowed and neglected by the sensational Coolgardie discoveries in the early nineties, is now receiving renewed attention. Another progressive district is Meekatharra, where the mines are opening up well. The production of the Mount Margaret field fell off for a time owing to the suspension of operations in the Lancefield mine, but with the remodeling of the plant this mine again entered the list of producers. The decrease at Coolgardie is largely attributed to the lessened output from the Westralia East Extension mine at Bonnievale, and the Burbanks Birthday mine at Burbanks, but several new mines are developing well, and the industry generally can be said to be on the up grade. The mines at Day Dawn exhibit a decreased yield mainly due to the reduced output from the Great Fingall mine.

Of the important mines outside of the Kalgoorlie-Boulder field the Sons of Gwalia occupies the premier position. The large and consistent orebodies of this mine are developing most satisfactorily. The completion of the railway to Norseman has improved mining conditions there, and besides cheapening costs has stimulated interest in the field.

In the northern goldfields—Kimberley, Pilbarra, West Pilbarra, Ashburton, and Gascoyne—mining is quiet, but the construction of the Port Hedland & Marble Bar railway now under way, and the consequent reduction in transport charges, should give an impetus to operations.

In Victoria the retrogression noticed in the previous year was not arrested, and a further falling off in the yield has to be recorded. On the principal field, Bendigo, operations were, however, attended with greatly improved results and the yields recorded for the first 10 months of the year 1909 are the best since the year 1904. It is also pleasing to note that the dividends for the first nine months of 1909 reached a total of £123,488, as compared with £97,370 for the same period in 1908. The full benefit of the dead work performed during the preceding year was reaped, and, taken altogether, the results contributed by the mines on this field were satisfactory. It is particularly noticeable, however, that the gold was won from the shallower levels, operations at depth not having been attended with the results anticipated. Dredging and sluicing operations still continue to contribute good returns. The decreased production is mainly due to the lessened output from the quartz mines at Walhalla, and from the deep alluvial workings.

The output from Queensland approached closely to that of the preceding year. During the early months of the year under review the yield was unfavorably affected by the falls of roof at the Mount Morgan mine, which necessitated the suspension of operations at a place from which large supplies of ore were being drawn. It was not possible to face the contingency immediately and to secure sufficient ore from other parts of the mine, so that several of the furnaces had to be closed down for a period. The difficulties were subsequently surmounted, and during the closing months of the year the deficiency was rapidly liquidated. While there is nothing to record in the way of exceptional discoveries, still there was a steady and consistent output from the principal fields, including Charters Towers and Gympie.

In New South Wales gold mining was particularly lifeless. The bulk of the yield continues to be furnished by the mines on the Cobar field, and by the dredges. The output from the Adelong division exhibits a satisfactory increase, but against this there was a considerable falling off in the yields from the Wyalong and Hillgrove fields. The State has been favored with exceptionally good seasons, and the pastoral and agricultural industries have found employment for so many additional hands that gold mining, or more particularly the prospecting for gold, has been comparatively neglected.

In Tasmania the yield was contributed mainly by the Tasmania gold mine at Beaconsfield, and by the Mount Lyell mines.

In South Australia the small returns from the gold mines at Mount Torrens, Petersburg, Glenloth, and Tarcoola were supplemented by contributions from the mines at Arltunga and MacDonnell ranges in the northern territory; also by the gold recovered by the Wallaroo & Moonta Copper Company. Reports of recent discoveries at Tanami in the northern territory are such as to emphasize the future possibilities of the "dead heart" of Australia.

In New Zealand the Waihi mine contributed another magnificent output. During the period ending with the first week in August this mine contributed gold to the value of £569,855, which brought the total value of the yield up to that date to £7,790,090. The dividends paid to Dec. 1, 1909, totaled £3,615,188. The Talisman Consolidated mine on the Karangahake goldfield is the next important producer and the operations conducted during the year have been attended with the most gratifying results. The additions and improvements made in the plants at these mines enabled an increased tonnage to be dealt with, and the indications point to a still larger output being contributed during the coming year. Dredging operations, though not conducted to the same extent as in previous years, still continued to supply good yields in the aggregate. Alluvial mining did not make any noteworthy progress, and owing to the gradual exhaustion of the deposits a decreased output from this source is naturally to be expected. Taken altogether gold mining in New Zealand is in a flourishing condition.

PRODUCTION OF SILVER-LEAD MINES OF NEW SOUTH WALES.

Year.	Metal Produced Within the Commonwealth.				Concentrates Exported.					Total Value of Product.
						Contents by Average Assay.			Value of the Concentrates.	
	Silver.	Lead.	Spelter.	Value.	Quantity.	Silver.	Lead.	(a) Zinc.		
	oz. fine.	tons.	tons.	£	tons.	oz. fine.	tons.	tons.	£	£
1903.......	6,489,689	92,293	286	1,790,929	76,824	1,736,512	29,706	14,625	308,714	2,099,643
1904.......	7,751,667	106,038	299	2,088,784	140,464	2,945,058	59,507	22,318	642,125	2,730,909
1905.......	6,804.934	93,182	544	2,131,317	270,474	3,480,561	69,044	30,637	1,181,720	3,313,037
1906.......	5,575,410	79,925	1,008	2,112,977	165,151	3,111,013	58,683	33,427	1,876,834	3,989,811
1907.......	5,921,457	79,870	984	2,228,420	337,823	6,228,225	111,830	76'645	3,574,775	5,803,195
1908.......	6,484,288	103,371	1,065	2,008,410	330,812	5,499,381	69,501	113,853	2,400,997	4,409,407
1909.......	3,717,016	64,821	......	1,176,394	409,438	6,867,775	90,307	144,018	2,707,680	3,884,074
Total....	42,744,461	619,500	4,186	13,537,231	1,730,986	29,868,525	488,578	435,523	12,692,845	26,230,076

(a) Zinc contents only ascertained where payment is made for same, i.e., not in lead concentrates.

The year's results in silver mining proved disappointing, as, owing to labor troubles, operations on the Broken Hill field were suspended at several of the large mines from the beginning of January until early in May. The ore raised during the year consequntly showed a decrease of 417,217 tons. The above statement shows the product of the silver-lead mines of New South Wales during the past seven years, and the value accruing to the Commonwealth of Australia.

The Broken Hill Proprietary Company did not resume mining on the termination of the miners' strike, but entered into a contract with several of the other companies for the purchase of lead concentrates, while the retreatment plants were kept running on the tailings which have accumulated to the extent of some 3,000,000 tons. The developments at the lower levels of the mine were unsatisfactory, but it is estimated that there are still several million tons of ore remaining to be extracted. Work is not, however, likely to be resumed below ground until a substantial rise takes place in the prices of metals. The fire in Block 11 mine is kept well in check. The output of this company for the half-year ending with May was only 438,109 oz. silver and 7609 tons of lead, as compared with 2,926,148 oz. silver and 47,842 tons of lead for the previous half-year. At the South mine it is estimated that the reserves of ore in sight above the 970-ft. level are sufficient to enable the present rate of output to be maintained for at least 13 years. The new mill is kept running full time treating about 7000 tons of ore weekly and producing 1000 tons of concentrates, and an appreciable reduction in working costs is shown. At the Central mine the bottom levels are developing better than expected, and a big lode has been located at the 1100-ft. level. A good deal of ground crushed by the creep has again been opened up for production. At Block 10 mine a new level is being opened at a depth of 1615 ft., as on account of the orebody's being comparatively narrow, operations have to be vigorously prosecuted at the deeper levels to keep the mill supplied. Block 14 mine is producing carbonate ore, and no attempt is being made to work the sulphide ores. The developments in the North mine below ground have proved encouraging. The new mill is now in operation, and a large output of concentrates is being maintained. The British and Junction mines remain closed.

In Queensland operations at the Mungana mines were affected first by a subsidence in the upper levels of the Lady Jane mine, and afterward

PRODUCTION OF SILVER IN AUSTRALASIA.

State.	1907.		1908.		1909.	
	Ounces.	Commercial Value.	Ounces.	Commercial Value.	Ounces.	Commercial Value.
New South Wales (a)	12,149,682	$7,937,016	11,983,669	$6,332,657	10,584,791	$5,451,167
Queensland	921,497	601,986	1,162,276	573,648	1,001,383	515,712
South Australia	5,845	3,791	....	....	1,660	855
Tasmania	2,850,000	1,861,820	(e) 2,400,000	1,260,000	(e) 2,500,000	1,287,500
Victoria	31,661	20,683	23,490	12,587	21,655	11,152
Commonwealth	15,958,685	$10,425,296	15,569,435	$8,178,892	14,109,489	$7,266,386
New Zealand	1,562,603	1,020,802	1,731,336	852,137	1,813,831	879,038
Total	17,521,288	$11,446,098	17,300,771	$9,031,029	15,923,320	$8,145,424

(a) Metal produced in Australia, plus silver contents of concentrates exported.

by a fire in the workings. However, at the Girofla mines work was pushed to maintain supplies of ore for the smelteries. The output of this State for the year was 1,001,383 oz. silver and 5,240 tons lead.

In Tasmania the Zeehan, Dundas, Rosebery and Mt. Farrell mines were persistently worked. The output of silver-lead ore from this State amounted to 80,378 tons, valued at £298,880.

The silver contained in the gold ores of New Zealand, mined during the year, amounted to 1,813,831 oz., valued at £180,872.

Canada.—The value of the gold produced by the whole Dominion during 1909 is estimated at $10,050,000, as compared with $9,842,105 during 1908. The yield from British Columbia fell from $5,929,880 in 1908 to $5,767,500 in 1909, but this decrease was more than offset by a large increase in the yield from Yukon Territory, which afforded $3,-600,000 in 1908 and an estimated value of $3,960,000 in 1909. The gold production of Nova Scotia increased only slightly.

The rapid growth of Canada's silver production during the past few years continued during 1909. Increased production is reported from both British Columbia and Ontario. In Ontario, where the production is practically all from the Cobalt district, a portion of the ores (8384 tons in 1909) is treated in Canadian metallurgical works producing silver bullion, white arsenic, and a speiss containing silver, cobalt, nickel, etc., the remainder of the ore being exported for treatment abroad. The total production of recoverable silver in Canada during 1909 is estimated at 27,878,590 oz., valued at $14,358,310. The production from the Cobalt district again shows a considerable increase over the previous year, but not so large an advance as was made in 1908 over 1907. According to returns received from 31 shipping mines, during 1909 about 28,042 tons of ore and 2967 tons of concentrates were shipped. The silver contents of ore shipped was returned as 22,581,788 oz., or an average of 805.28 oz. per ton, and for the concentrates shipped 3,639,-475 oz., or an average of 1,226.65 oz. per ton. Bullion shipped from the mines contained 143,440 fine oz. silver. The total silver contents of ore, concentrates and bullion shipped from the Ontario mines was 26,364,703 oz. The mine owners receive payment for only 93 to 98 per cent. of the silver contents; and in valuing the production a deduction of 5 per cent. is made from silver contained in ore and concentrates to cover losses in smelting and refining. On this basis, the silver recovery is estimated at 25,128,590 oz. Payments for cobalt contents were reported as $90,750; the total value of the year's output was a little over $13,000,000, without deductions for freight and treatment charges. The number of men employed in shipping mines was reported as 2768, and wages paid \$2,396,742. Incomplete returns of concentration showed 127,271 tons of ore treated, producing 3213 tons of concentrates. In 1908 the shipments were 25,682 tons of ore and concentrates containing 19,398,545 oz. of silver, or an average of 755 oz. per ton.

Exports of silver from the whole of Canada in 1909 were 31,126,504 ounces.

British Columbia (By E. Jacobs).—The shortage in the placer gold output is attributable to a restricted supply of water. Provision is being made in Cariboo for extended operations during 1910, chiefly on the properties of John Hopp, near Barkerville, and the leases represented by H. W. DuBois. These leasers are constructing a 20-mile ditch and flume from Swift River to the Quesnel Forks, preparatory to hydraulicking on a large scale. There was no dredging for gold in the province in 1909, though a number of bars in the Fraser river were prospected. The Guggenheim hydraulic properties in British Columbia, in the Quesnel Forks and Atlin camps, were not worked during the season on the large scale that was expected. Recently a move was made to work some placer leases situated in the Big Bend of the Columbia district, north of Revelstoke, where good results were obtained in earlier years.

GOLD AND SILVER PRODUCTION OF BRITISH COLUMBIA.

	1906.		1907.		1908.		1909.	
	Oz.	Value. (a)	Oz.	Value. (a)	Oz.	Value. (a)	Oz.	Value. (a)
Gold, placer....	47,420	\$948,400	41,400	\$828,000	32,350	\$647,000	30,000	\$600,000
Gold, lode.....	224,027	4,630,638	196,179	4,055,020	255,582	5,282,880	250,000	5,167,500
Total gold...	271,447	\$5,579,038	237,579	\$4,883,020	287,932	\$5,929,880	280,000	\$5,767,500
Silver..........	2,990,262	1,997,226	2,745,448	1,793,519	2,631,389	1,321,483	3,000,00C	1,470,000

(a) Placer gold is valued at \$20 per oz.; lode gold at \$20.67 per oz.; silver at average market quotations.

The decrease in the production of lode gold occurred largely in Rossland, a result of the suspension of production at the Le Roi mine, pending systematic exploration in the deeper levels of the mine. The Center Star group of the Consolidated Mining and Smelting Company made a slightly larger production of gold than in 1908, and the Le Roi No. 2 equalled its 1908 production from its Josie mine.

The Boundary district, as in earlier years, made a fairly large production of gold, which in the mines of that district is in association with copper. The greater part of the lode gold produced in British Columbia came from smelting ores; in only two mining divisions were gold ores milled to any considerable extent, viz.: Nelson and Osoyoos. The Nickel Plate mine at Hedley was sold during the year to the Hedley

Gold Mining Company. Development and new construction will be done on the Nickel Plate in 1910, following extensive diamond drilling in 1909.

The advance in the Nelson district came mostly from Sheep Creek camp, in which several mines were developed with promising results. At Ymir the only producer was the Yankee Girl, operated by a New York company organized during the year. Texada Island made an increased output of lode gold from ore containing also silver and copper.

Nearly half of the increase in silver output was made in Ainsworth camp, in West Kootenay. The Blue Bell mine on Kootenay lake contributed about 38,000 oz. more than in 1908; the Whitewater and Whitewater Deep mines, situated between that lake and the Slocan mining division, about 58,000 oz., and various other mines in the division together made up about 75,000 oz. of the total increase. In the Slocan division the Richmond-Eureka mine produced 197,000 oz., 37,000 oz. more than in 1908, while the Van Roi, an English-owned property, yielded an increase of about 38,000 oz. On the Hewitt-Lorna Doone group much silver-zinc ore was blocked out, but none was shipped in 1909.

The production of East Kootenay mines was nearly 100,000 oz. less than in 1908. Several mines in the Nelson division, the Silver Cup in Ferguson camp, Lardeau, and the Marble Bay and Cornell mines on Texada Island increased their silver output. The finding of native silver in bornite ore at between 900 and 1000 ft. depth in the Marble Bay mine was one of the most interesting features of the year's mining in the Coast district; the more so since the first-class ore also contained about $10 per ton in gold.

The average silver content of the ores of the big Boundary mines appeared to be slightly lower than in earlier years; the difference per ton was not considerable, but in the aggregate silver content of the total tonnage—nearly 1,600,000 tons—mined and smelted, it was distinctly noticeable.

Nova Scotia.—The production of gold in Nova Scotia in 1909 was 12,500 oz., a slight increase over 1908. The principal producers were the New England Mining Company (formerly the Boston Richardson) at Goldboro; the Oldham Sterling Gold Company, at Oldham; the Great Bras d'Or Gold Mining Company at Middle river, Cape Breton; the Ponhook Mining Company at Malaga, and the Sydney Gold Mining Company at Country Harbor. Altogether about 25 mines were in operation, employing a total of 550 men.

Ontario.—The yield of gold in 1909 is estimated at $65,000, as compared with $60,337 in 1908. It came mainly from the Laurentian mine in the Manitou region. Considerable excitement was aroused by the discovery of gold in the Porcupine Lake region, which lies west of Night Hawk Lake on the Hudson Bay side of the Hight of Land. A large number of claims were staked, following upon the finding of free gold in quartz in a number of places, and some of the properties give promise of being valuable. A good deal of the territory is covered with drift, which makes prospecting difficult. A rush into this district was in progress as the year closed.

Ontario (By Thomas W. Gibson).—Ontario is now easily first among the silver-producing communities of America, its annual output being little short of that of Colorado, Montana and Utah combined, and nearly 50 per cent. of the entire production of the United States. In 1909 the output was 25,885,983 oz., having a value of $12,500,000. In 1903 there was practically no silver produced in Ontario. In 1904 the first ore was raised at Cobalt, and to the end of 1909 the total yield was about 63,000,000 oz., worth $33,000,000.

Though Cobalt is without doubt the richest silver field that has been opened anywhere during the present generation, no one can tell how much longer the present rate of production can be maintained. The probability is, however, that the camp will be a producer for years to come. The mines are worked wholly for their silver contents. The ore contains other elements of value, namely, cobalt, nickel and arsenic, but the latter two bring no returns to the mine owner, and the enforced production of cobalt ore is far in excess of the world's consumption. The greater number of the veins at Cobalt occur in conglomerate of Lower Huronian age; perhaps 90 or 95 per cent. of the production has been from this conglomerate. Veins are also found in the diabase and in the Keewatin, some of them quite rich.

The chief producers during the year were Nipissing, Crown Reserve, O'Brien, La Rose, Kerr Lake, Coniagas, Trethewey, Buffalo, Temiskaming & Hudson Bay, clustering around Cobalt station on the Temiskaming & Northern Ontario railway. In southeastern Coleman the Temiskaming worked rich but somewhat irregular deposits in the Keewatin, and ore was also found on the adjoining property, the Beaver. In the neighboring camp of South Lorrain, to the east, several mines are likely to become of importance, the one in the most advanced stage of development being the Wettlaufer. Anvil Lake, Elk Lake and Gowganda are still under development, and some properties, among them, the Millereth or Blackburn, Reeves-Dobie, and Boyd-Gordon will make shipments or ore during the present winter. None of these camps, however, has so far proved equal to Cobalt.

Concentration plants for low-grade ore are becoming numerous in the Cobalt camp, and most of the high-grade ore is treated in Ontario. There are reduction works at Copper Cliff, Deloro and Thorold. Part of the high-grade ore and most of the low-grade goes to the smelters in the United States.

(By R. E. Hore).—An important advance at Cobalt during 1909 was the construction of plants on the Montreal and Matabitchouan rivers, which will supply the camp with cheap power. The Cobalt Hydraulic Power Company is installing, at Ragged Chute, a 550-h.p. air-compressing plant which is the largest in the district. The air is compressed by the Taylor hydraulic system and collected in a rock chamber under a pressure of 125 lb. The air is conducted to Cobalt, about eight miles, through a 20-in. steel pipe and will be distributed to the mines by loop lines of 12-in. pipe. The same company is already supplying electric power to the mines. The Mines Power, Limited, is putting in a plant on the Matabitchouan river, 25 miles from Cobalt, to develop electric power. The water will drive four turbines, direct connected with generators. The power will be transmitted by aluminum wire to three substations at Cobalt, Kerr Lake and South Lorrain. At the first two stations there will be electrically driven compressor plants, and air will be delivered by pipe lines to the surrounding mines. Beach Bros. have installed a plant at Hound Chute. The head is 35 ft. and the power available is utilized to drive four water wheels connected with as many generators. Power is transmitted by copper wire to Cobalt, from which the plant is six miles distant.

In 1909 concentration became for the first time an important factor in the Cobalt distict. Early in 1908 three mills were in successful operation and at the beginning of 1909 three others had begun to treat ore. During the summer two more were added and others are now nearly completed. In the three plants, first in operation, treatment was uniform in reducing with crushers and rolls and sizing in trommels. In the later plants stamps are used with more satisfactory results. In treating the pulp from the stamps, Wilfley and James tables and Callow tanks are used. During the year two plants were installed to treat slimes by the cyanide process without amalgamation, and are said to be working satisfactorily. The two mines, Buffalo and O'Brien, recently made shipments of bullion resulting from this treatment.

The Nipissing Mining Company during 1909 produced 4,646,876 oz. of silver at a cost of 16.39c. per oz., leaving a net profit of $1,687,000, out of which it paid $1,535,000 in dividends. The net surplus of the company was $913,195 at the end of the year.

The shipments during the year are given in the following table:

NIPISSING SHIPMENTS IN 1909.

	Tons.	Silver oz. Per Ton.	Net Value Per Ton.	Total Silver, Oz.
High-grade	1047.69	3,093.71	$1518.17	3,241,259
Low-grade silicious ore	5174.20	212.23	84.88	1,098,167
Concentrates	183.07	855.42	400.73	156,606
Nuggets	7.63	19,771.12	9844.94	150.844
Total	6412.59	724.64	$339.68	4,646,876

The high-grade ore contained 8.46 per cent. cobalt and 6.98 per cent. nickel, and the concentrate contained 8.32 per cent. cobalt and 3.78 per cent. nickel. Sales of cobalt amounted to 177,706 lb., worth $19,833, and of nickel 117 lb., bringing $14.

COSTS AT NIPISSING.

	Total.	Per Ton Ore.	Per Oz. Silver.
Trenching	$26,669	....	....
Development	144,714	....	....
Tunnels and shafts	71,039	....	....
Stoping	81,685	....	....
Sorting and loading	33,943	....	....
Office and general	96,141	....	....
Total mine operation	$454,191	$71.06	$0.0961
Concentration	35,434	5.54	0.0075
Depreciation	49,799	7.79	0.0105
Marketing, etc	263,224	41.18	0.0557
Corporation, etc	12,483	1.95	0.0026
	$815,131	$127.52	$0.1724
Less miscellaneous	40,320	6.30	0.0085
Total cost of production	$774,811	$121.22	$0.1639

Work was carried on in 1909 through 10 shafts and two tunnels, and a total of 4504 ft. of drifting, 2528 ft. of crosscutting, 996 ft. of raising, 423 ft. of sinking and 9483 cu.yd. of stoping were done. An average of 87 men were employed five and one-half months in the trenches, of which 33.1 miles, averaging 3.4 ft. deep were dug. This work was entirely confined to the central area, which had already been prospected. The management proposes to remove the overburden from the entire surface of the property. The area of the Nipissing property includes 429 acres of conglomerate, of which 306 acres has been partially prospected; Keewatin, 176 acres, partially prospected, 157 acres; Diabase, 241 acres, partially prospected, 16 acres.

The Nipissing Reduction Company, a custom concentrator on Nipissing ground, treated the low-grade ore from No. 63 vein. Its operations are given as illustrating the present milling of Cobalt ores: Dry weight concentrated, 11,159 tons; silver contents of ore, 311,824 oz. (27.94 oz. per ton); concentrates produced, 264.44 tons; silver contents of concentrates, 246,426 oz. (932 oz. per ton).

The ore reserves are estimated by Manager Watson as 6,539,200 oz. silver in 10 veins, more than three times the reserve of a year ago. The estimate is based largely on past results, and when an orebody is cut through by a drift and is not further developed by winzes or raises, ore is estimated not further than 10 ft. above or below the tunnel. The known veins on the property now number 132, and one vein discovered during 1909, No. 122, has already produced over 400,000 oz. of silver. The largest production was made from No. 63 vein. Winzes sunk below the 146-ft. level showed conglomerate at 45 ft. and ore is probably below the present depth of working. The largest vein is No. 64, which shows 30 in. of ore at one place.

The Crown Reserve Mining Company owns 23 acres of mining property and leases the adjoining property of the Silver Leaf Company, comprising 35 acres. The report of the company for the year ended Dec. 31, 1909, states that 4,034,325 oz. silver were produced, of a gross value of $2,080,156, at a total cost of $416,141, or 10⅓c. per oz. This was obtained from 756.9 tons of high-grade ore with an average content of 4784.7 oz. per ton, 2332.3 tons of low-grade ore carrying 148.4 oz. per ton, and 3093 oz. bullion which was 869 fine. This production was about one-sixth of the output of the Cobalt district. Five dividends, amounting to $1,238,170, were paid and the company closed the year with a surplus of $549,275. The company has a complete plant, $65,403 having been spent in equipment in 1909. The total amount of development on the property is 4932 ft. and about 12,500 sq.ft. of vein have been stoped. About one-fifth of the property has been developed.

Yukon Territory.—The Yukon Gold Company, working seven dredges and three electrically operated elevators, had a successful season. The Northern Light and Power Company, a new enterprise, is installing machinery for the generation of electricity which will supply low-cost power. Beside the Yukon Gold Company's dredges, others did well. During the 1909 season Bonanza Basin, Old Discovery, Bear Creek and Stewart River dredges were all at work. On the Guggenheims' 70-mile ditch, from Tombstone mountain, about 600 men were employed and the work was so far advanced that the ditch was used with water running at half capacity.

The North American Transportation and Trading Company did work preparatory to installing gold dredges next season. It is stated that the company will operate along different lines from those followed by the

Guggenheims—hydraulicking off the top dirt and leaving the frozen gravel to thaw gradually instead of thawing by steam jet. While this method will take longer, it is thought that it will be cheaper. The company's operations will be on Sixty-Mile.

In Wheaton and Conrad camps prospects for quartz mining are considered promising. Ores in these camps carry silver and gold. In the Whitehorse copper camp, mining is at a standstill, attributed to high freight rates over the White Pass & Yukon railway, so that present cost of shipping to a smeltery would be too great for profitable working. Discovery of coal in considerable quantity, situated within 40 miles of where dredges and hydraulic plants are working, is expected to prove a valuable aid to hydraulic and other gold mining.

GOLD PRODUCTION OF YUKON TERRITORY.

Year.	Amount.	Year.	Amount.	Year.	Amount.	Year.	Amount.	Year.	Amount.
1896.	$300,000	1899.	$16,000,000	1902.	$14,500,000	1905.	$7,000,000	1908.	$3,600,000
1897.	2,500,000	1900.	22,275,000	1903.	12,250,000	1906.	6,000,000	1909.	3,960,000
1898.	10,000,000	1901.	18,000,000	1904.	10,350,000	1907.	3,150,000		

The Yukon Gold Company during 1909 earned a gross return of $1,747,599 and a net profit of $691,682. A total of 3,087,427 cu.yd. of gravel was handled. The Yukon country, in 1909, experienced a late spring with a correspondingly late opening of navigation and mining. The dredging season for six out of the seven dredges was 132½ days as against a normal season of 140 days. The dredges during the season handled 2,381,880 cu.yd., and produced $1,363,722 worth of gold. The value per cu.yd. was 57.24c. and the cost 31.94c. per cu.yd. This cost includes all thawing charges—amounting to 15.45c. per yd.—preliminary stripping operations and depreciation at the rate of $2000 per month per dredge. As an example of what may be expected in ground entirely thawed, the No. 1 dredge handled in the month of August, 100,217 yd. at a cost of 9.28c. per yard. It is worthy of note that the actual value per yard of material handled exceeded the estimated value based on examination results by 16.8 per cent. The cost per yard was 6 per cent. higher than the estimated cost for the season, but it is less than the estimated average cost for handling the creek deposit by 8.6 per cent. The dredges operated 83.5 per cent. of the possible running time.

In the hydraulic mines a total of 705,544 cu.yd. was handled during 1909. The total gross production was $383,877. The cost of this work, including the heavy charge for ditch maintenance was $294,811. The hydraulic mines which were open at the beginning of the season actually operated an average of 23.46 days out of a season of 142 days in 1909, or $16\frac{1}{2}$ per cent. of the time. The yardage handled was small and the gross cost about the same as if a much larger yardage had been moved. The causes for the failure of the hydraulic operations to come up to expectations may be briefly summarized as follows: (1) Delays and difficulties in the first year's operation of the main ditch due to breaks in bad ground and pipe line troubles. The result was a loss in operating time in the opened mines, and the work of opening the mines for full capacity was held back. These troubles were anticipated to a great extent, but more time was required for pipe-line repairs than estimated. (2) Complications with neighboring owners, which resulted in the stoppage of work on Jackson and Bear creeks. (3) Unusually poor season for local water supply on which the elevator operations were dependent. (4) Delay in receipt of materials, particularly pipe line needed for completion of the Bonanza Extension of the main ditch. This delay made the Upper Bonanza operation dependent on local rainfall, which was the lowest ever known in the Yukon, resulting in decreased production and high cost.

China (By T. T. Read).—Practically all the gold produced in China is exported, none being used for coins and comparatively little in the industrial arts. The export of dust and bars during 1908 was approximately $6,500,000, an unusually large amount, the export being stimulated by the prevailing low price of silver during the year. The chief producing districts are the alluvial workings along the southern borders of the Amur and Ussuri rivers in Northern Manchuria and Mongolia, Shantung and southwestern China also being important sources of supply. There is also a certain production of silver in southwestern China, but the amount of this is difficult to ascertain, as it is impossible to distinguish bar silver, shipped in the ordinary course of trade, from the product of the mines.

Dutch East Indies.—Few outside of the Dutch East Indies are aware of the extent to which the mining industry has progressed in these islands. Probably 50 companies have been promoted and at present there are about 15 operating mines. The localities in which active mining is being carried on are: Redjang Lebong, Sumatra; Dutch Borneo and both coasts of North Celebes.

Redjang Lebong may fairly claim to rank among the notable mines of the world. Its monthly output averages about $165,000. The mine is situated about 90 miles from the coast, a little west of north from Benkoelen. Steam traction engines have lately been introduced to facilitate transport. The ore mined averages about 1 oz. gold per ton and carries from seven to eight times as much silver as gold by weight. The ore is reduced by stamps and tube mills, and practically the whole extraction is made at the cyanide plant. The Lebong Siman and Lebong Soelip companies operate in the same region and may be regarded as offshoots from Redjang Lebong. Both appear to have excellent prospects; the former has just reached the crushing stage, while the latter has been producing for over a year and in May, 1909, returned $47,500.

The Totok, in North Celebes, now appears to be entering upon a prosperous career, the grade of ore having lately improved. The average output for 1908 was $18,750 per month. The average value of the ore crushed has for a long time been just over 4 dwt. per ton, varying between 2 dwt. and 1 oz.; the average value has lately risen to over 5 dwt. The ore is free-milling and contains some magnetite and traces of chalcopyrite. The mill equipment at the Totok comprises 40 stamps in two mills of 20 heads each, two Huntingtons and a puddler plant for washing clay from such rock as requires this treatment. Cyaniding was formerly tried, but the peculiar adaptability of this ore to amalgamation makes this treatment unnecessary. Mercury is fed into the mortars and each stamp is operated at a duty of 4½ tons per 24 hours, crushing through a 30-mesh screen. The amalgam, after squeezing, contains from 39 to 53 per cent. gold. The bullion runs high in silver, the average content being about 697 gold and 280 silver.

The Palehleh is another mine which has had a very hard existence. The production, however, has been slowly improving; in May, 1909, the output amounted to $15,700. Large quantities of concentrates are produced and these were formerly smelted by the Soemalata company, but they are now being stored and will presumably be treated on the spot. The Soemalata, which recently closed down, is situated not far from the Palehleh property. The ore is exceedingly refractory, smelting being the only possible treatment, and this apparently was not very successful.

India.—The output of gold in India during 1908 was valued at $10,584,336, of which Mysore contributed $9,990,056. Complete figures for 1909 are not yet available, but the output of the Kolar field, Mysore, during the past year, was valued at $10,120,032, equivalent to an increase of 9592 oz. of crude bullion, whence it appears that the output of the whole of India will show an increase.

The report of the Mysore Gold Mining Company, which contributes almost half of the output of Mysore, shows that during 1909 the battery of 210 stamps of that company crushed 234,500 long tons of quartz from which gold to the value of £894,834 was recovered, equal to an extraction of 76.3s. per long ton or 67.9s. ($16.52) per short ton. Most of the gold is won by amalgamation, 83.4 per cent. of the total value of the ore being recovered by this process. The ore averaged 19 dwt., 8 grains of fine gold per ton. The balance of the recovery was obtained by cyanidation. The actual tonnage handled by the cyanide department was 190,388 tons of tailings. The cyanide and zinc consumption per long ton was 0.57 and 0.07 lb. respectively.

Since the beginning of its operations in 1884 the company has crushed 2,452,959 long tons of ore; has treated 2,105,245 tons of tailings and has recovered a gross value of £11,680,522, out of which it has distributed £5,935,094 as dividends. On the basis of one long ton of ore treated, the average recovery has been 91.5s., of which 48.4s. has been paid to stockholders. The average costs, therefore, including the unknown amount that has been put back as capital for extensions, have been about 43s. per long ton or 38s. ($9.24) per short ton. During 1909 the costs, according to the revenue and expenditure account, which includes London expenditure, amounted to 33.2s. per long ton milled, or, including depreciation and amounts written off machinery and plant, etc., 36.6s. per ton.

The development of the mine continues to be of a satisfactory character. In the Ribblesdale section the lode is exposed at a depth of over 4000 ft., maintaining its width and richness. In Tennant's section the depth is not far short of 3000 ft. At the deepest level the lode is 6 ft. wide and averages over an ounce of gold to the ton. The southern section, McTaggart's, has been less productive during 1909 than formerly. The reserves of ore are stated to be over one million tons, which is a four-years' supply for the mill at the present rate of crushing.

Mexico.—The output of gold in Mexico during the calendar year 1909 is estimated by the statistical division of the treasury department at 33,876 kg., as compared with 30,914 kg. in 1908, 28,109 kg. in 1907 and 27,888 kg. in 1906. The department of finance, basing its calculations on the relative exports, imports, coinage and consumption of gold in the arts, estimates the production of gold during the fiscal year ending June 30, 1909, at 33,761 kg. The output of silver during the calendar year 1909 is estimated by the statistical division of the treasury department at 2,259,830 kg., as compared with 2,258,081 kg. in 1908, 1,901,935 kg. in 1907, and 1,727,890 in 1906. The department of finance, computing in the same manner as for gold, estimates the production of silver during the fiscal year ending June 30, 1909, at 2,292,260 kg.

The increase in the output of silver came mainly from the older camps in which many mills using modern processes and treating large tonnages are now in operation. It is to be noticed that this large silver production comes largely from low-grade ore, running perhaps as high as 1000 grams (32.15 troy oz.) in silver. Much that is treated contains from 400 to 800 grams of silver per ton. Some of the mines of Mexico produce rich ore, 7 to 20 kg. per ton, but this is the exception.

The greater part of the gold production was obtained in connection with the silver output. The gold ratio to silver is fairly constant in most of the camps and runs from 4 to 10 grams of gold to the kilogram of silver. This was largely lost in the old patio process, but with the introduction of cyanidation most of this gold is recovered. Considerable gold was produced in connection with the copper output of the country, which after several months' suspension is now greater than ever before. The El Oro camp in Mexico produced mainly gold. There are gold districts in Oaxaca, Puebla, Sonora and Colima, but the operations in ~~most~~ of these, at present, are on a small scale.

Practically no successful placer or gravel operations are under way in Mexico at the present time. The reported rich placers of Sinaloa have been examined and condemned by American dredging engineers. The elaborate attempt to operate placers in eastern Chihuahua has so far failed. Some placer gold is obtained in Sonora, in the Altar district and also from the Fuerte and Yaqui Rivers. Recent developments in the Altar district have been very encouraging. Several attempts have been made to develop the gold district in Oaxaca, with the prospect of successful operation of several small properties. The most notable gold property in Mexico, the Lluvia del Oro in Chihuahua, was hindered during 1909 by the delay in the installation of necessary machinery. An English-owned gold property at Mezquital del Oro in Zacatecas was recently revived.

No notable new silver or gold districts were discovered during 1909, but development of the older districts, Guanajuato, Pachuca, El Oro, Parral, Santa Eulalia, etc., gave much encouragement as to the future production of the low-grade, silicous and carbonate silver-bearing ores. The Santa Gertrudis mine at Pachuca was sold to English capitalists for $4,000,000 in gold.

Rhodesia (By W. Fischer Wilkinson).—The gold production of southern Rhodesia, that is of Rhodesia south of the Zambesi river, for 1909 was valued at £2,623,709, or somewhat in excess of the production of the previous year. As in 1908, the production was largely made up by a large number of small producers. There were about 115 companies or individuals making returns, a large number of whom worked with a five-stamp battery, or with chilean mills, Huntington mills, Wheeler pans or dollies. The 14 largest companies mentioned in the table accounted for about 46 per cent. of the output. The 101 other producers had, therefore, an average output of about £14,000.

The most important mines as far as output is concerned were the Globe & Phœnix and the Eldorado. The former mine has been working a number of years, and is probably the deepest mine in the country, the main shaft being 2300 ft. deep. The ore reserves, which on Dec. 31, 1908, had a gross value of £485,020, were estimated on Sept. 30, 1909, to have a value of £1,045,151. The Eldorado mine, which commenced crushing in 1907, also turned out well. During the year a fresh issue of capital was made for the purpose of adding to the plant and for sinking a new main shaft and an extension shaft.

GOLD PRODUCTION OF SOUTHERN RHODESIA TO DECEMBER 31, 1909.

	Tons Milled.	Gold, Oz.	Value.	Value per Ton.
Prior to Sept. 1, 1898	(a)	6,471	£23,456	
Sept. 1, 1898, to June 30, 1899	81,841	48,847	177,072	43.26s.
July 1, 1899, to June 30, 1900	104,746	57,621	208,877	39.88
July 1, 1900, to March 31, 1901	140,716	89,258	320,457	45.54
Year ending March 31, 1902	249,667	180,910	640,661	51.32
Year ending March 31, 1903	338,156	201,107	709,461	41.96
Year ending March 31, 1904	516,747	234,693	845,359	32.71
Year ending March 31, 1905	787,936	309,516	1,113,068	28.25
Year ending March 31, 1906	1,100,609	435,019	1,556,741	28.28
April 1, 1906, to December 31, 1906	1,051,908	426,333	1,531,481	29.10
Year ending December 31, 1907	1,610,875	612,052	2,178,886	27.05
Year ending December 31, 1908	1,819,230	606,962	2,526,006	27.77
Year ending December 31, 1909	1,807,431	623,388	2,623,709	29.03
	9,609,862	3,832,177	£14,455,234	30.08s.

(a) No details available.

The Selukwe, one of the oldest mines in the country, was a producer, the gold won in the last financial year having amounted to over £63,000, but the operations were carried on at a loss. The Wanderer mine has been working a low-grade, auriferous deposit in the Selukwe district for some years, but has not been a financial success. During 1909 a reconstruction of the capital was made to purchase the Camperdown property, which will be brought into connection with the Wanderer mill by a ropeway two or three miles in length. The Wanderer mine was worked as a quarry and the ore milled by a dry-crushing plant.

The Giant mine, which had to curtail operations in 1908 on account of the collapse of its main shaft, will shortly be milling on the old basis. The mill is being increased by 15 stamps and an output of 12,000 tons monthly arranged for. The new shaft, which is timbered with steel sets, was down to the sixth level (708 ft.) in July. The ore body is a wide schistose lode. On June 30, 1909, the ore reserves were 204,846 tons, valued at 10.4 dwt. The mine is expected to be one of the largest gold producers of Rhodesia.

The most interesting event of 1909 was the discovery of an auriferous conglomerate in the Abercorn district, at a place situated about 60 miles northeast of Salisbury. The Shamva property, on which the most work has been done, has a line of old workings approximately 1500 ft. in length. The Consolidated Goldfields of South Africa has acquired a large interest in this property.

Russia.—The gold production of Russia, as reported to the Imperial Mint, to which the law requires all gold to be delivered, is reported for seven years past as follows: 1903, 2302.175 poods; 1904, 2281.825; 1905, 2016.900; 1906, 2262.475; 1907, 2314.450; 1908, 2584.750; 1909, 3129.400 poods. (1 pood=526.4 troy oz.) It is usual in estimating the actual production to allow 10 per cent. for gold concealed, or not delivered to the Mint. Many engineers who have had experience in that country think that the allowance is too small. Estimating on that basis, however, the gold production of Russia for 1909 was 1,812,448 oz., valued at $37,455,032, an increase of $6,510,471 over 1908. The gain was chiefly from the operations of a few companies, notably the Lena Gold Mining Company, Ltd., and of several new mines in Siberia.

PRODUCTION AND DIVIDENDS OF PRINCIPAL MINES IN SOUTHERN RHODESIA IN 1909.

Mine.	Tons Milled. (2000lb.)	No. Stamps.	Other Crushing Machines.	Days Milling.	Duty per Stamp per Day.	Value of Yield.	Value per Ton.	Dividends Distributed.
Battlefields	32,529	0	2 Huntingtons, 1 Chilean, 2 pans	......	....	£62,542	38.45s.	....
Bucks (a)	6,254	8	....	158	4.98	50,199	161.80	£90,000
Bushtick	61,282	20	1 Chilean, 2 pans	273	11.20	31,050	10.13	....
East Gwanda	83,104	60	1 Chilean	327	4.23	91,503	22.02	....
Eldorado	78,436	20	2 Chileans, 8 pans	344	11.41	185,031	47.18	90,000
Gaika	31,247	5	1 Chilean	283	22.10	57,256	36.64	....
Giant	61,470	15	1 Tube mill	281	14.50	75,295	24.49	....
Globe & Phoenix	74,492	40	3 Wheeler pans	336	5.54	279,138	74.94	70,000
Jumbo	33,233	30	....	316	3.53	88,278	53.12	....
Lonely	11,777	10	....	329	4.33	56,252	95.52	....
Penhalonga	116,400	60	4 Huntingtons	326	5.95	84,764	14.56	....
Selukwe	56,447	40	....	321	4.40	66,047	23.40	....
Surprise	29,643	20	....	334	4.44	44,338	29.91	....
Wanderer	186,558	0	4 Gates rolls	301	....	68,266	7.31	....

(a) Includes Bucks Reef Syndicate and Bucks Reef Gold Mines.

On the basis of the first half of 1909 the Ural district reported 24 per cent. of the total; the Tomsk district, or West Siberia, 12.3 per cent.; the Irkutsk and Amur districts, West Siberia, 60.3 per cent. A further analysis shows that 74 per cent. of the yield was from placers worked in the ordinary way; 4 per cent. from dredges; 0.4 per cent. from hydraulic operations; a total of 78.4 per cent. from placers. The remaining 21.6 per cent. was from quartz mines, chiefly in the Ural district, 18.9 per cent. being obtained by milling and 2.7 per cent. by cyanide and other chemical processes.

The increase of production does not imply an improvement in Russian gold mining at the end of 1909. The gain was due chiefly to the large increase in production of three or four companies, which have adopted improved methods, or which are working new districts. In fact, considering the area of ground worked, the average production has rather decreased. The adverse conditions are most marked in the Ural district. In the Southern Ural the Kochkar system, from which brilliant results were expected in former times, has now partially failed and is making very poor returns. Some of the workings show a loss and the remainder have been supported chiefly by the lixiviation of the old tailings, which had accumulated at the mines. Some of the older mines in the Ural mountains have been worked nearly 100 years, a few 150 years, and can no longer be exploited profitably by the present system. Not enough new mines have been opened to take the place of these old operations.

The most promising region in Russia is in the basins of the Vitim and Olekma rivers in the Irkutsk province and extending over into the Yakutsk province. These goldfields are notable for their extent and for the high content of gold in the gravels. This district in West Siberia gives about one-third of the total yield of gold in Russia. In East Siberia, in the Amur and the Seacoast districts, the gold placers already show signs of exhaustion. This is especially the case in the Amur where Blagoviestchenk, formerly the center of an important field, is now almost deserted, and other places are in the same condition. New methods of working are being tried, especially excavators and dredges, in the placers of these provinces. Besides the exhaustion of some mining districts East Siberia has suffered very much from the lack of labor. The Chinese and Koreans, who formerly worked there in large numbers, are now excluded by the government and are not allowed in the mines.

Gold dredging in Russia develops slowly, notwithstanding the number of low-grade placers where it is believed that dredges could be profitably employed. One reason for this is the lack of the capital necessary to install the machinery; another is the failure of a number of dredges, which were set at work without proper preliminary investigation of the ground, and were not adapted to the local conditions. There are now about 60 dredges at work in the goldfields, but a number of them are operated at a loss.

Transvaal (By W. Fischer Wilkinson).—The total gold production of the Transvaal for 1909 amounted to £30,925,788, which is £968,178 in excess of the production of 1908. The accompanying table shows—

TABLE I. YEARLY PRODUCTION OF TRANSVAAL MINES.
(Chamber of Mines Returns.)

Year.	Witwatersrand District.			Outside Mines Value.	Transvaal Total.
	Tons Milled.	Value.	Value per Ton Milled. Shillings.		
1884–9	1,000,000	£2,440,000	48.83	£238,231	£2,678,231
1890	730,000	1,735,491	47.4	134,154	1,869,645
1891	1,154,144	2,556,328	44.2	367,977	2,924,305
1892	1,979,354	4,297,610	43.4	243,461	4,541,071
1893	2,203,704	5,187,206	47.0	293,292	5,480,498
1894	2,830,885	6,963,100	49.2	704,052	7,667,152
1895	3,456,575	7,840,770	45.2	728,776	8,569,555
1896	4,011,697	7,864,341	39.2	739,480	8,603,821
1897	5,325,355	10,583,616	39.74	1,070,109	11,653,725
1898	7,331,446	15,141,376	41.3	1,099,254	16,240,630
1899	6,872,750	15,067,473	48.84	661,220	15,728,693
1900	459,018	1,510,131	65.82	....	1,510,131
1901	412,006	1,014,687	49.25	81,364	1,096,051
1902	3,416,813	7,179,074	42.00	74,591	7,253,665
1903	6,105,016	12,146,307	39.79	442,941	12,589,248
1904	8,058,295	15,539,219	38.46	515,590	16,054,809
1905	11,160,422	19,991,658	35.82	810,416	20,802,074
1906	13,571,554	23,615,400	34.8	964,587	24,579,987
1907	15,523,229	26,421,837	34.04	981,901	27,403,738
1908	18,196,589	28,810,393	31.6	1,147,217	29,957,610
1909	20,543,759	29,900,359	29.1	1,025,429	30,925,788

if the war period is neglected—a constant increase year by year. In spite of the enormous production there is good reason for predicting that the zenith has not yet been reached. The limiting factor today is not so much the extent of ground suitable for mining as the labor for exploiting the mines; as difficulty is now being experienced in providing for present requirements, rapid expansion in the gold output is not to be expected.

To illustrate the progress that is being made, it is interesting to compare the returns of the mines of the Witwatersrand district for the month of September with the corresponding figures for the same month of the previous year. In September, 1909, 600 additional stamps were working

TABLE II. RETURNS FROM TRANSVAAL ORES.

Year.	Recovery per Ton	Costs per per Ton.	Dividend per Ton.	Year.	Recovery per Ton.	Costs per Ton.	Dividend per Ton.
	s.	s.	s.		s.	s.	s.
1897	39.7	29.6	10.2	1905	35.8	27.2	8.5
1898	41.3	28.0	13.0	1906	34.8	26.4	8.2
1899	43.8	34.8	8.9	1907	34.0	25.0	9.0
1903†	39.8	28.8	11.0	1908	31.6	22.2	9.4
1904	38.5	29.0	9.5	1909	29.1	20.0	9.1

† 1900-1902 War period.

and 39 additional tube mills, with the result that the tonnage milled increased 13.4 per cent. The average grade of ore treated, however, was lower by 2s. 6d., and the costs by 6d. per ton, or considerably less than the fall in grade. The total value of gold won was 3.6 per cent. in excess of that won during the same period in 1908. The net profit per ton fell by about 15 per cent.

It will be noticed in the table of production and from Table II that the grade of ore milled, as measured by the yield, which was about 92 per cent. of the original value, was lower than that treated in 1908, and considerably less than 10 years ago; indeed, the figures rather understate the fall in grade because the extraction is now generally higher than in former years. This reduction of grade was due mainly to the deliberate policy of taking out of the mines ore of lower quality than was formerly mined. The effect of this policy is, of course, to lower costs,

TABLE III. DISTRIBUTION OF GOLD WON IN THE TRANSVAAL.

Year to June 30.	1906.		1907.		1908.		1909.	
	£	Per Cent.	£	Per Cent.	£	Per Cent.	£	Per Cent.
Working costs	14,637,043	66.23	17,000,000	63.813	16,600,000	58.2	17,860,000	57.64
Dividends	5,234,750	23.69	6,750,000	25.337	8,000,000	28.1	9,300,000	30.01
Profits tax	475,000	2.15	600,000	2.252	740,000	2.6	928,275	3.00
Reserve fund, Debenture Redemption, Machinery Renewals, etc.	1,753,914	7.93	2,290,490	8.598	3,168,368	11.1	2,897,693	9.35
	22,100,707	100.00	26,640,490	100.00	28,508,368	100.00	30,985,966	100.00

Note—Compiled by Consolidated Goldfields of South Africa from Mines Department statistics.

as the wider the stopes the less is the cost of mining. It has also the effect of adding considerably to the gross production of gold in any particular area. In all mines are ores ranging in value from zero up to the highest grade, and one of the most difficult problems that a mine manager has to face is to decide what is the ideal grade. If he mines closely he gets a large profit, high costs and a reduced life. If he aims at getting every ton of ore out of the mine that will pay expenses he gets low costs, small profits or none at all, and a long life. He has, therefore, to strike the happy medium and extract a grade of ore that will give what he considers the best results. Opinions differ as to whether the policy of including low-grade ore has not, in the majority of cases, been carried too far. I think that it has, and that in many cases a raising of the grade at the expense of longevity and the working costs would produce better financial results for the shareholders.

Owing largely to the policy of working lower-grade ores, costs showed a marked diminution over those of previous years. The larger scale of working also had a beneficial effect in reducing costs, as it allowed the fixed charges to be spread over a larger tonnage. Besides the reductions resulting from the above causes, reductions were made by improved methods of mining and by increased efficiency of labor. The system of breaking ore on day shift alone was adopted at several mines with great advantage to ventilation and, therefore, to the efficiency of the workers. The single-shift system also allowed better supervision. The increased use of electric power contributed considerably to the reduction in costs. In metallurgical work benefits were obtained through the use of heavier stamps and of improved appliances for handling sands.

TABLE IV. ANALYSIS OF WORKING COSTS IN THE TRANSVAAL.

Year to June 30.	1906.		1907.		1908.		1909.	
	£	Per Cent.	£	Per Cent.	£	Per Cent.	£	Per Cent.
White wages	5,049,780	34.5	5,946,000	34.98	5,650,000	34.0	6,050,000	33.87
Colored and Chinese	2,781,038	19.0	3,241,900	19.07	3,400,000	20.5	3,900,000	21.84
Stores	5,781,632	39.5	6,439,600	37.88	6,300,000	38.0	6,630,000	37.12
Sundries	1,024,593	7.0	1,371,900	8.07	1,250,000	7.5	1,280,000	7.17
	14,637,043	100.0	17,000,000	100.00	16,600,000	100.0	17,860,000	100.00

Note—Compiled by Consolidated Goldfields of South Africa from Mines Department statistics.

There were thus several influences at work to bring about a reduction in costs, and it is not easy to apportion them. The popular explanation is that this reduction was due to large-scale working, an explanation which the advocates of consolidations strongly support. But, although some appreciable reduction was no doubt due to this cause, owing, as noted above, to the reduced weight of fixed charges, I believe it is mainly the policy of working poorer ores that has created the fall in costs. Both breaking and development benefit largely by the adoption of this method of working.

The favorable influence of modern plants and shafts must also be noted. One of the most cheaply worked mines, as well as one of the deepest, is the Simmer Deep. During September, 1909, the costs at this mine were only 12s. 7d. per ton, and that on a production by no means the largest on the field. These costs compare favorably with an old-established mine like the Robinson Deep, which works a larger tonnage for 16s. 6d. per ton. As a general rule, it will be found that the mines with the lowest costs are those with wide reefs and large mills. Where the reefs are narrow and where, consequently, a large production cannot be maintained, the costs are comparatively high, but it does not follow that the mines are being less efficiently worked. To illustrate the general effect of large-scale working, the accompanying analysis (Table V) of 60 companies making returns for August, 1909, has been prepared.

The results obtained by the six largest producers during August, 1909, are given in Table VI. In the Randfontein South, the East Rand and the Crown mines the milling plant is not in one unit.

TABLE V. AVERAGE MINING COSTS ON THE RAND.

Tons Milled per Month.	Number of Companies.	Average Cost per Ton Milled.
		s. d.
Under 10,000 tons	12	22 8
10,000 to 20,000	15	19 2
20,000 to 30,000	12	17 4
30,000 to 40,000	8	16 2
40,000 to 50,000	7	15 0
Over 50,000	6	15 4

Perhaps one of the best ways of illustrating the reduction in costs and in what departments the chief savings were made will be by giving the detailed costs over a number of years at the Simmer & Jack mine, one of the outcrop companies, which at present is the cheapest worked mine on the field. The reduction in underground costs is striking. Since 1908 the mine was worked on day shift alone, a system that has proved very economical.

TABLE VI. COSTS AT THE LARGE MINES.
August, 1909.

	Yield per Ton Milled.	Costs per Ton Milled.	Profit per Ton Milled.
	s. d.	s. d.	s. d.
Knights Deep	21 5	12 6	8 8
Randfontein South	28 9	19 2*	9 6*
Robinson Deep	26 9	16 9	9 8
Simmer & Jack	26 4	11 10	14 3
East Rand Proprietary	29 3	15 2	13 9
Crown Mines	33 11	16 4	17 2

* Estimated.

The question that agitated the mining community most during 1909 was the native-labor supply. Table VIII shows the latest statistics of white, colored and Chinese labor employed in the gold mines of the Transvaal, as well as the figures for previous years. The figures are encouraging, showing a steady increase in spite of the repatriation of the Chinese. During the later months of the year there was a falling off in Kafirs which caused considerable alarm, and the outlook for the future was not promising. The recruiting agencies are making greater

TABLE VII. WORKING COSTS AT THE SIMMER & JACK.

Year Ended June 30.	1905.	1906.	1907.	1908.	1909.
Tons milled	475,181	624,507	717,524	785,310	831,040
	s. d.	s. d.	s. d.	s. d.	s. d.
Mining, hauling and pumping	14 3	12 4	11 0	8 11	6 4
Transport of quartz; crushing and sorting; milling and cyaniding	5 0	4 7	4 3	4 2	3 9
Development and redemption	2 6	2 6	2 6	1 9	1 9
General charges, renewals, maintenance, etc.	1 6	1 0	1 7	1 5	1 3
Total costs	23 3	20 5	19 4	16 3	13 1
Total yield	32 0	31 10	33 5*	33 4	29 9
Total profits	8 9	11 5	14 1	17 1	16 8

* Includes 1s. 3d. reserve gold declared.

efforts, and the shortage is being met to some extent by increased efficiency in the native himself and by the practice of greater economy in labor on the part of the managers. The statistics also show an increase in the employment of white labor, the ratio in August being 1 white to 7.7 natives. As an example of what can be done by better organization attention may be called to the case of the Simmer & Jack where, during the last financial year, a larger tonnage was treated with fewer natives. The tonnage increase was 5.8 per cent. and the labor decrease was 12 per cent. The repatriation of the Chinese laborers continued during the year and it is expected that by April, 1910, all will have gone.

The dividends declared during the year by the Witwatersrand companies were £9,310,751 and by the outside mines, £193,870, making a total of £9,504,621.

The policy of amalgamating companies into larger units, which was discussed at some length in the 1908 review, was continued during 1909.

TABLE VIII. LABOR EMPLOYED IN TRANSVAAL GOLD MINES.

(Mines Department Statistics.)

		White.	Colored.	Chinese.	Total Colored and Chinese.
1902	July	8,162	32,616	....	32,616
	Dec.	10,292	45,698	....	45,698
1903	June	11,825	66,221	....	66,221
	Dec.	12,695	73,558	....	73,558
1904	June	13,413	74,632	1,004	75,636
	Dec.	15,023	83,639	20,885	104,524
1905	June	16,939	104,902	41,340	146,242
	Dec.	18,159	93,831	47,267	141,098
1906	June	17,959	90,882	52,352	143,234
	Dec.	17,166	98,156	52,917	151,073
1907	June	17,697	111,862	51,517	163,379
	Dec.	17,697	129,618	37,118	166,736
1908	June	18,181	147,557	21,460	169,017
	Dec.	19,605	164,826	12,275	177,101
1909	June	21,620	175,895	7,317	183,212
	Dec.	23,077	168,665	2,038	170.703

The most notable of the amalgamations is that of the Crown Mines, a company formed to acquire several of the most important companies of the central Rand. The advantages officially claimed for the amalgamation were as follows: (1) Considerable prolongation of profitable life, which materially reduces the annual amount investors should set aside for amortization. (2) Increased facilities for maintaining a regular grade of ore. (3) Increased facilities for reducing working costs without impairing efficiency, by centralization of administration and concentration of work. Such reduction spread over the life of the amalgamated company will amount to an important sum.

Other amalgamations that took place during the year were: The Kleinfontein Deep and the Van Ryn Deep; the Ferguson, East Randfontein, Van Hulsteyn and Johnson combined into the Randfontein Central; the Consolidated Main Reef, the Main Reef East and the Main Reef Deep absorbed by the Consolidated Main Reef; the Rand Klipfontein and the Klipfontein Estate amalgamated into a company called the Rand Klip; the Lancaster and Lancaster West; the Robinson, Porges, South, North and Stubbs Randfontein into the Randfontein South; the Langlaagte Estate, Langlaagte Block B, and the Langlaagte Exploration absorbed by the Langlaagte Estate; the Geldenhuis Estate, Geldenhuis Deep and Jumpers Deep absorbed by the Geldenhuis Deep; the Rose Deep and Glen Deep, the combined companies being continued under the name of the Rose Deep.

TABLE IX. DIVIDENDS PAID BY TRANSVAAL GOLD MINING COMPANIES.

Year.	Dividends.	Year.	Dividends.	Year.	Dividends.
1887	£12,976	1895	£2,046,852	1903	£3,362,237
1888	112,802	1896	1,513,682	1904	3,928,487
1889	432,541	1897	2,707,181	1905	4,857,539
1890	254,551	1808	4,864,973	1906	5,735,161
1891	334,698	1899	3,109,041	1907	7,131,612
1892	901,470	1900	Nil	1908	8,751,282
1893	955.358	1901	415,813	1909	9,501,621
1894	1,532,284	1902	2,121,126		

Besides these amalgamations, several of the companies were reconstructed for the purpose of obtaining fresh working capital or additional claims. Among these may be mentioned the Aurora West, the Brakpan, the Western Rand Estates Company, the Main Reef West, the Rand Collieries, the Apex Company, the Meyer & Charlton, the West Rand Consolidated and the Van Dyk. An important change in ownership took place when the Rand Mines Deep Company sold its property to the Rand Mines, Ltd. The reconstruction that has been going on has brought out a large amount of fresh capital, most of which has gone toward developing the eastern Rand. In the western end of the Rand, activity was not so great, and the goldfield from a producing point of view may still be said to end at Randfontein. On the Western Rand Estates, where the Randfontein series is claimed to have been proved by boring some years back, active development is proposed, so that perhaps in the near future this end of the Rand may attract more attention.

An event of the year was the calling for tenders for leases of mining ground owned by the Government. Two areas on the farm Modderfontein, one in the central Rand, one on the farm Zaaiplaats and one at Boksburg, were offered, the conditions being that a sum of money calculated to be sufficient to bring the mine to a producing stage should be guaranteeed and that a percentage of the profits based on a sliding scale should be paid to the Government. A further condition was that a portion of the capital should be offered for subscription to residents in the Transvaal.

A feature of the year's work was the negotiations between the mine owners and the Government with regard to the mining rights of *bewaarplaatsen,* that is, areas reserved for surface plant, the storage of water or tailings, etc. Under the gold law the mining rights under these areas are vested in the Government; they are, as a rule, too small to be worked separately, and can be profitably exploited only by the adjoining mines. After protracted negotiations between the mining groups and the Government it has been agreed that the mining rights are to be allocated to the mining companies for an amount equivalent to 75 per cent. of the estimated distributable profits, less 2s. 6d. per ton crushed. The amount so estimated will be converted into a percentage of the net produce of the enlarged company and will be payable simultaneously with the 10 per cent. profit tax over the life of the mine. When the present value of the mining rights to be absorbed by any company is less than £10,000, cash will be paid, and when it is between £10,000 and £20,000 the company can pay either cash or a percentage of net produce, at its option. The Meyer & Charlton mine, which was specially excluded from the negotiations, agreed to absorb the rights allocated to it for the equivalent of 50 per cent. of the distributable profit, the present value of which is calculated to be equal to from 10 to 15 per cent. of the annual profits of the mine. It is satisfactory that a basis for valuation has at last been arranged, but it is a pity that it should be so complicated.

As regards the continuation of the gold to greater depths the work during the year was satisfactory. Whether the formation becomes impoverished in depth has always been a mooted subject, and even today it is impossible to give a decided answer one way or the other. The falling off in the average yield from year to year is largely due to the practice of working poorer ores than formerly, and is, of course, no proof of impoverishment. The evidence now available seems to indicate that the values will vary in the deeper workings, just as they do near the surface. At all events, in some of the deepest workings, such as at the City Deep and at Brakpan, good ore was found, while in other places the grade shows a distinct falling off in depth.

The deepest workings on the central Rand are those of the Village Deep, where the reefs have been cut by the Turf shaft at a depth of about 4000 ft. Only a small amount of development was carried out, but that done was not especially encouraging. The report for September gives the following results: South reef at 16th level, 38.5 in., 7.3 dwt.; main reef leader at 17th level, east drive, 58 ft. reef, 51.57 in., 4.89 dwt.; west drive, 64 ft. reef, 44.85 in., 4.03 dwt. A note is made that in the above exposures of south reef and main reef leader there are included upper bands of very low grade which, if persistently poor, might be excluded from stoping operations, thus improving the average grade. In the 18th level the main reef leader, when first cut, showed an average width of 45 in., and an average assay of 13.1 dwt. The City Deep development afforded strong evidence of the occurrence of payable ores at great depths. The workings of this mine are at a depth of 3000 ft., and up to Sept. 30, 1909, the tonnage exposed amounted to nearly 1,500,000 tons averaging 8.9 dwt. (37s.), over a stoping width of 64 inches. In the far-eastern Rand good assays were also secured at great depths at Brakpan, where the samplings over a length of 6647 ft. of reef showed a width of 37.2 in., averaging 7.8 dwt. The ore reserves in this mine were estimated in round figures at 400,000 tons, from which 29s. per ton can be recovered. In this mine the main reef was intersected in No. 2 shaft at a depth of 3695 ft. On the Van Dyk mine, on the other hand, the development work has given disappointing results. At the Simmer Deep and Jupiter mines, which are worked at a depth of from 3000 to 4000 ft., crushing returns of about 18s. and 23s. per ton, respectively, have been obtained during the last six months of the year. At the Cinderella Deep, another deep mine, a yield of 29s. per ton has been obtained for several months.

West Africa, Gold Coast and Ashanti (By W. Fischer Wilkinson).—The gold production of the Gold Coast and Ashanti, West Africa, during 1909 amounted in value to £955,635, an output considerably below that won during 1908, the reason being that several of the mills were shut down. The principal producing mines and the total output for the last thirty years are given in the accompanying tables.

GOLD PRODUCTION OF GOLD COAST COLONY AND ASHANTI, SINCE 1880.

Year.	£	Year.	£	Year.	£	Year.	£	Year.	£
1880....	32,865	1886.....	74,878	1892.....	98,805	1898.....	63,837	1904.....	345,608
1881....	45,240	1887.....	81,168	1893.....	79,099	1899.....	51,299	1905.....	657,330
1882....	61,188	1888.....	86,510	1894.....	76,795	1900.....	38,006	1906.....	877,568
1883....	52,435	1889.....	103,200	1895.....	91,497	1901.....	22,186	1907.....	1,154,885
1884....	66,188	1890.....	91,657	1896.....	86,186	1902.....	96,880	1908.....	1,182,680
1885....	89,981	1891.....	88,112	1897.....	84,797	1903.....	254,790	1909.....	955,635

The Ashanti Goldfields and Abosso improved their production as compared with 1908, but Taquah and Broomassie did not do so well. Bibani remained about the same. Prestea Block A. Abbontiakoon Block I, and Wassau, which gave a considerable production in 1908, milled only in the early months of 1909. The Akrokerri company, which appeared in the producing list in 1908, went into liquidation. The Ashanti Goldfields, Abosso, Prestea, and Abbontiakoon maintained their grade, but the others showed a decrease, which was especially marked as regards Taquah and Broomassie.

At the close of 1909 the list of producing companies, excluding dredging companies, was reduced to four. The other mines, which had been producing gold in 1907 and 1908, but without profit, continued operations underground with the intention of restarting milling on a larger scale at a later date and under more favorable conditions. It is hoped that a considerable reduction in the costs of working may be brought about partly by increasing the output and partly by more efficient management.

As regards the cost of the working mines the accompanying figures taken from the reports of the Ashanti Goldfields, the Taquah and the Abosso are of interest.

MINING COSTS IN WEST AFRICA.

Mine.	Period.	Tons (2000 lb.) Milled.	Yield per Ton.	Total Operating Costs per Ton Including Development and Depreciation.
			s.	s.
Ashanti Goldfields...	1907–8	66,254	52.2	36.4
Ashanti Goldfields...	1908–9	78,786	44.0	31.3
Abosso.............	1907–8	44,021	50.4	39.6
Abosso.............	1908–9	60,702	45.6	37.6
Taquah.............	Sept. '07–June '08	46,234	60.0	48.3
Taquah.............	1909–9	56,793	55.6	55.7

The costs of the Ashanti Goldfields for the financial year ending June 30, 1910, are made up of 22.3s. per short ton for mining, milling and general charges; and 14.1s. per ton for freight on bullion, government royalty, general expenses in London, mine development and depreciation of plant and machinery. The corresponding figures for the year 1908-9 were 21.4s. and 10s. Of the tonnage milled, about one-sixth was derived from a quarry, where the mining costs were comparatively low. The Abosso costs for 1907-8 include a development charge of 5.25s. and a depreciation charge of 4.4s. per ton. In 1908-9 these items were 4.5s. and 3.6s. per ton respectively. The Taquah costs for 1907-8 include 6.5s. for development and 6.2s. for depreciation. For 1908-9 the development charge was the same, but depreciation amounted to 8s. per ton milled. The high costs of this year are attributed to heavy floods and machinery troubles. Ultimately the costs at this mine should approximate those of the Abosso mine.

GOLD COAST AND ASHANTI PRODUCING MINES IN 1909.

Mine.	Tons. (2000 lb.)	Value. of Yield.	Value. per Ton.
		£	s.
Ashanti Goldfields	92,869	227,768	49
Abosso	72,262	165,295	45.7
Taquah	60,778	141,164	46.5
Broomassie (*a*)	20,036	81,268	81.1
Bibiani	64,485	98,651	30.6
Abbontiakoon (*b*)	27,439	48,218	34.6
Wassau (*c*)	22,250	29,050	27.8
Prestea, Block A (*d*)	46,500	79,377	34
Dredging Companies	....	84,844	....
		955,635	

(*a*) Mill shut down September; development of mine being continued. (*b*) Mill shut down June; development of mine being continued. (*c*) Mill shut down May; development of mine being continued. (*d*) Mill shut down July; development of mine being continued.

Note—The tonnages of the Ashanti Goldfields and of Bibiani, officially given in long tons have been computed to short tons.

The Ashanti Goldfields Corporation improved its position decidedly during 1909 and is now perhaps the strongest mining company in the colony. Justice's Find, the new orebody of great width and value discovered in 1908, continued to open up well, and the development of the mines at Obuasi was of a favorable character. The main oreshoot of the Obuasi mine, which was cut at the third level of the Ashanti mine last year, was further developed on that level as well as on the sixth level. On the third level the oreshoot was proved to have an average width of 8 ft. and an average value of 3 oz. gold for a length of 502 ft. On the sixth level the same oreshoot proved to be shorter—about 220 ft. long—and to assay 27 dwt. over a width of 15 ft. The ore reserves at all the mines at the end of October were valued at over half a million tons of a gross value of two million pounds sterling, with an estimated profit in sight of over a million sterling. For the year ended June 30, 1909, 70,345 long tons were milled, yielding bullion to the amount of £174,368 or 49s. 5d. per ton (44s. per short ton of 2000 lb.). The cost of mining, milling and general mine expenditure was 24s. ($5.84) per long ton. Freight and insurance of bullion, London expenses and the royalty of 5 per cent. of the gross value of bullion payable to the government came to 4s. 7d. per ton. Depreciation and development account for 6s. 7d. per ton, making altogether a working cost of 35s. 2d. ($8.56) per long ton. The development expenditure charged to working cost, it may be noticed, was only 25 per cent. of the expenditure incurred during the year, and though it may be a fair figure, it would have been sounder policy to have charged it all away to working expenditure.

The process of amalgamation followed by cyaniding was discarded, as no better extraction than 60 per cent. could be obtained by that method. The ore coming from the mine is now crushed dry in ball mills, roasted in Edwards furnaces and leached with cyanide solution, an extraction of 93.5 per cent. being obtained. The oxidized ore from Justice's Find is crushed wet and filter-pressed, at a cost of 10s. per ton for treatment and 4s. for quarrying, an extraction of 87.2 per cent. being obtained. The Obuasi ore yielded 15.14 dwt. and Justice's Find ore yielded 14.76 dwt. per ton. Having regard to the large increase in the ore reserves it was decided to increase the capacity of the reduction plant from 7000 to 10,000 tons per month, when it is expected that the total costs will be 32s. per ton of 2240 lb., and the profits about £24,000 per month.

ORE RESERVES IN GOLD COAST AND ASHANTI MINES.

Mine.	Date.	Tons. (2000 lb.)	Value per Ton in Dwt.
Abbontiakoon	Dec. 31, 1909	196,312	12.9
Abosso	June 30, 1909	350,888	14.4
Ashanti Goldfields	Oct. 31, 1909	581,616	16.2
Taquah	June 30, 1909	141,187	15.6
Prestea (Block A)	July 31, 1909	327,000	11.0
Wassau	Sept. 30, 1909	175,052	10.6
Cinnamon Bippo	June 30, 1909	213,000	7.97

The market valuation of West African mining stock now runs into millions and the future is alarmingly discounted. The gold production is now about one million sterling and the profits probably scarcely one-tenth of that. Very large increases are therefore needed to justify the prices at which the mines are now valued. Most of the money recently subscribed will go into the mines which are crushing or have been crushing, but some of it will be employed in testing the ground between the known oreshoots. The evidence so far obtained has not encouraged the belief that the veins are payable over wide areas, as in the Rand.

The London Silver Market in 1909.

According to Pixley & Abell, the year 1909 was marked by generally low prices and moderate fluctuations. London handles nearly two-thirds of the silver production of the world, and the markets everywhere are ruled by its prices. The accompanying table shows the imports of silver into Great Britain; the exports of silver to the Far East—India, China, Japan and the Straits; the highest and lowest prices in London, in pence per sterling ounce, for the past 10 years.

SILVER STATISTICS OF LONDON.

Year.	Imports, Value.	Exports to the East, Value.	London Price.	
			High.	Low.
1900	£13,322,300	£9,985,642	$30\frac{3}{16}$	27
1901	11,501,678	9,018,419	$29\frac{9}{16}$	$24\frac{15}{16}$
1902	9,764,296	7,565,305	$26\frac{1}{8}$	$21\frac{13}{16}$
1903	10,310,330	8,051,780	$28\frac{1}{2}$	$21\frac{11}{16}$
1904	11,687,339	10,038,319	$28\frac{9}{16}$	$24\frac{7}{16}$
1905	12,992,014	8,643,405	$30\frac{5}{16}$	$25\frac{7}{16}$
1906	17,288,063	15,565,304	$33\frac{1}{8}$	29
1907	15,983,892	12,752,230	$32\frac{7}{16}$	$24\frac{3}{16}$
1908	10,326,889	10,243,968	27	22
1909	11,814,889	8,936,715	$24\frac{7}{8}$	$23\frac{1}{16}$

The smallest exports to the East were in 1902; the largest in 1906. Those of 1909 were less than those of six years out of the ten given. The comparative steadiness of the market in 1909 should be noted, the range between the highest and lowest price being $1\frac{13}{16}$d. only, against 5d. in 1908, and $8\frac{1}{4}$d. in 1907. India and China were the largest operators in the market, and most of the important movements were due to their actions.

Shipments to India, though less than in 1908, continued on a large scale and amounted to about £6,750,000 while the stock held in Bombay at the end of 1909 was £1,000,000 with nearly £500,000 on the water, against a stock of £400,000 and £840,000 in transit at the end of 1908. With the excellent crops of cotton and other produce in India, it is anticipated that there will be a large demand for silver for jewelry and hoarding during 1910, though, judging from the increased shipments of gold to India during the last few months, it is probable that a greater proportion of gold than usual will absorb the savings of the people. The speculation to which reference was made last year continued until recently, and at one time it was estimated that Indian speculators had sold short on this market to the extent of $2,000,000. During the last few months, however, this was largely liquidated. This buying was probably the principal cause of the steadiness of the market during the later months of the year.

The Indian government again made no purchase. Its total holdings of silver rupees, which at the beginning of the year stood at about 46 crores (£30,500,000), increased during the summer to 49 crores (£32,-500,000), but during the last few months, owing to the demand for currency to move the heavy crops referred to above, these stocks were reduced to 38¾ crores (£25,825,000) and it is probable further large reductions will be made during the early months of 1910.

China was a larger and more important buyer in 1909 than usual, though at times, when quotations suited, she sold freely. In addition to her operations on this market, she also bought and sold largely in Bombay, while from San Francisco she received upward of £1,500,000, against £1,100,000 in 1908. The low rates of exchange ruling in China again adversely affected the import trade, while exports for the same reason were stimulated. In Shanghai the stock of sycee, which at the beginning of 1909 amounted to 19,000,000 taels, was reduced to 14,200,-000 taels at the end of the year. Shipments of silver from London to China during 1909 amounted to nearly £2,000,000, against £821,000 in 1908, but these figures are not necessarily correct, for silver shipped to China from London is often diverted while in transit to India, while shipments to India are in the same way diverted to China.

Coinage by the London mint for home use was on a small scale, but purchases were made for colonial coinage, notably for the new silver currency of Australia. The well-appointed mint of the Canadian government in Ottawa, which was completed a little over a year ago, is now supplying Canadian requirements. A few purchases were made by the countries comprising the Latin Union, but purchases by the American, French and Mexican governments were practically nothing. Rumania bought about £100,000 in May, while Brazil also took a moderate amount. Russia took over £1,000,000, of which a large part was probably intended for Manchuria, while to Germany about £1,500,000 was shipped for the increase of the silver currency referred to in the circular of 1908, though a portion may have found its way to Russia. It is also probable that Germany was largely interested in the important purchases made in December.

The average price for 1910 will probably be somewhat higher than that of 1909. The general improvement in trade, which is now becoming evident the world over, especially in India and China, where silver plays a most important part, and the tendency of several States to increase the amounts of silver subsidiary coinage in circulation, and so relieve the pressure on their gold reserves with profit to themselves, should lead to a good general demand for silver during the current year.

AVERAGE PRICE OF BAR SILVER IN LONDON, 1833-1909.

(In pence per standard ounce, 0.925 fine.)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year	Pence.
1833	59.1875	1843	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250
1834	59.9375	1844	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375
1835	59.6875	1845	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750
1836	60.0000	1846	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500
1837	59.5625	1847	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625
1838	59.5000	1848	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375
1839	60.3750	1849	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375
1840	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1902....	25.62	25.41	25.00	24.34	23.71	24.17	24.38	24.23	23.88	23.40	22.70	22.21	24.09
1903....	21.98	22.11	22.49	23.38	24.89	24.29	24.86	25.63	26.75	27.89	27.01	25.73	24.75
1904....	26.423	26.665	26.164	24.974	25.578	25.644	26.760	26.591	26.349	26.760	26.952	27.930	26.399
1905....	27.930	28.047	26.794	26.108	26.664	26.910	27.163	27.822	28.528	28.637	29.493	29.977	27.839
1906....	30.113	30.464	29.854	29.984	30.968	30.185	30.113	30.529	31.483	32.148	32.671	32.003	30.868
1907 ...	31.769	31.852	31.325	30.253	30.471	30.893	31.366	31.637	31.313	28.863	27.154	25.362	30.188
1908....	25.738	25.855	25.570	25.133	24.377	24.760	24.514	23.858	23.877	23.725	22.933	22.493	24.402
1909....	23.843	23.706	23.227	23.708	24.343	24.166	23.519	23.588	23.743	23.502	23.351	24.030	23.706

AVERAGE PRICE OF SILVER IN NEW YORK.

(In cents per fine ounce.)

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1902....	55.56	55.09	54.23	52.72	51.31	52.36	52.88	52.52	51.52	50.57	49.07	48.03	52.16
1903....	47.57	47.89	48.72	50.56	54.11	52.86	53.92	55.36	58.00	60.36	58.11	55.375	53.57
1904....	57.055	57.592	56.741	54.202	55.430	55.673	58.095	57.806	57.120	57.923	58.453	60.563	57.221
1905....	60.690	61.023	58.046	56.600	57.832	58.428	58.915	60.259	61.695	62.034	63.849	64.850	60.352
1906....	65.288	66.108	64.597	64.765	66.976	65.394	65.105	65.949	67.927	69.523	70.813	69.050	66.791
1907....	68.673	68.835	67.579	65.462	65.981	67.090	68.144	68.745	67.792	62.435	58.677	54.565	65.327
1908....	55.678	56.000	55.365	54.505	52.795	53.663	53.115	51.683	51.720	51.431	49.647	48.769	52.864
1909....	51.750	51.472	50.468	51.428	52.905	52.538	51.043	51.125	51.440	50.923	50.703	52.226	51.502

Commercial Movement of Gold and Silver

The movement of gold and silver in the United States, Great Britain and France is shown by the following tables:

GOLD IMPORTS AND EXPORTS, UNITED STATES.

	1904	1905	1906	1907	1908	1909
Imports	$84,803,234	$50,293,405	$155,579,380	$143,398,072	$50,276,293	$44,086,966
Exports	121,138,415	46,794,467	46,709,158	55,215,681	81,215,456	132,880,821
Balance	E $36,335,181	I $3,498,938	I $108,870,222	I $88,182,391	E $30,939,163	E $88,793,855

GOLD IMPORTS AND EXPORTS, GREAT BRITAIN.

	1904	1905	1906	1907	1908	1909
Imports	£33,876,588	£38,567,895	£46,042,590	£57,088,547	£46,146,314	£54,691,829
Exports	33,039,138	30,829,842	42,617,267	50,866,009	49,969,099	47,249,536
Excess Imports	£837,450	£7,738,053	£3,425,323	£6,222,538	(a)E £3,822,785	£7,442,293

(a) Excess Exports.

GOLD IMPORTS AND EXPORTS, FRANCE.

	1904	1905	1906	1907	1908	1909
	Francs	Francs	Francs	Francs	Francs	Francs
Imports	656,063,000	779,648,000	430,473,000	492,336,000	1,017,524,000	392,282,000
Exports	123,976,000	131,494,000	165,087,000	154,572,000	23,400,000	181,068,000
Excess Imports	532,087,000	648,154,000	265,386,000	337,764,000	994,124,000	211,214,000

GOLD HOLDINGS OF THE LEADING EUROPEAN BANKS.

First Week of January.	1906	1907	1908	1909	1910
Bank of England	$145,322,390	$165,383,645	$165,087,430	$155,863,180	$168,519,215
Bank of France	541,150,235	538,787,750	689,929,615	703,587,165	697,606,000
Bank of Germany	137,940,000	137,140,000	192,155,000	202,750,000	170,264,000
Austro-Hungarian Bank	233,045,000	228,795,000	244,860,000	246,325,000	282,090,000
Bank of Russia	589,520,000	607,125,000	606,805,000	605,440,000	704,450,000
Bank of the Netherlands	27,680,000	38,239,100	41,933,000	42,089,000	50,405,000
Belgian National Bank	17,076,665	17,610,000	20,103,335	21,166,665	21,196,665
Bank of Italy	159,440,000	193,320,000	187,000,000	187,965,000	192,750,000
Bank of Spain	76,840,000	78,210,000	78,965,000	79,060,000	80,585,000
Bank of Sweden	19,780,000	20,325,000	21,215,000	21 720,000	22,340,000
Bank of Switzerland	....	....	....	23,535,000	24,790,000
Bank of Norway	....	....	....	8,735,000	8,885,000
Total	$1,947,794,290	$2,024,935,295	$2,248,053,380	$2,298,236,010	$2,423,880,880

UNITED STATES: EXPORTS AND IMPORTS OF SILVER.

	1904	1905	1906	1907	1908	1909
Exports	$50,312,745	$57,513,102	$60,957,091	$61,625,886	$51,837,671	$57,592,309
Imports	26,087,042	35,939,135	44,227,841	45,912,360	42,224,130	46,151,282
Excess, exports	$24,225,703	$21,573,967	$16,729,250	$15,713,526	$9,613,541	$11,441,027

GREAT BRITAIN: EXPORTS AND IMPORTS OF SILVER.

	1904	1905	1906	1907	1908	1909
Exports	£13,263,694	£14,561,677	£18,865,285	£15,813,329	£13,283,888	£12,785,182
Imports	11,687,339	12,992,014	17,288,063	14,667,024	10,326,889	11,814,889
Excess, exports	£1,576,355	£1,569,663	£1,577,222	£1,146,305	£2,956,999	£970,293

FRANCE: EXPORTS AND IMPORTS OF SILVER.

	1906.	1907.	1908.	1909.
	Francs.	Francs.	Francs.	Francs.
Exports	170.983,000	202,313,000	159,746,000	130,863,000
Imports	164,637,000	182,146,000	155,733,000	147,865,000
Excess	E. 6,346,000	E. .20,167,000	E. 4,013,000	I. 17,002,000

EXPORTS OF SILVER FROM LONDON TO THE EAST. (*a*)

	1904	1905	1906	1907	1908	1909
India	£9,527,618	£7,230,421	£15,129,627	£10,531,354	£9,247,390	£6,667.600
China	512,792	886,847	433,957	417,350	741,400	1,950,000
The Straits	79,268	38,299	1,750	691,150	164,885	114,600
Total	£10,119,678	£8,155,567	£15,565,334	£11,639,854	£10,153,675	£8,732,200

(*a*) As reported by Pixley & Abell.

Cyanidation During 1909.

By Charles H. Fulton.

Nothing new of importance is to be recorded in cyanidation for the year 1909. The growth of the process was along conventional lines and was confined to the perfection of existing slime filters, agitators, and other appliances. The most noteworthy events of the year were the application of Caldecott's sand filter at the Simmer Deep in South Africa, and the perfection of the Oliver continuous slime filter. The latter is finding considerable application, and on acount of its simple mechanism seems to be the most promising of the automatic continuous filters. Progress was made in the cyanidation of silver ores, considerable experimetal work being carried out. Few mills were erected, and in general the activity in cyanidation was not as great as in 1908. A considerable portion of the literature for the year deals with experimental work in the laboratory rather than with actual practice. In Mexico, the McArthur-Forrest cyanide patents expired in October, 1907. The company claimed a right to a special extension of five years, which would make its patents expire in 1912, but its appeal was denied by the Government.

Milling Practice.

United States.—The mill of the Pittsburg-Silver Peak Gold Mining Company, near Blair, Nevada, is described by Henry Hanson[1] in some detail. It is a mill modeled on Homestake, South Dakota, practice and was briefly described last year.[2]

The first cyanide mill in America was built at Mercur, Utah,[3] and the Consolidated Mercur Gold Mining Company, the successor of the pioneer company, has since erected what was for a time the largest cyanide plant in the world, attracting widespread interest and attention. The mill has a dry-crushing and roasting plant, and it was here that the Moore slime filter was first tried extensively, but in its early form proved inefficient. In view of these facts the present practice at this mill is of interest, not, perhaps, that it is to be emulated, but to show what changes an old plant may go through in its practice. The accompanying flow sheet outlines the method of treatment. The cost of roasting, including maintenance and repair, during the last fiscal year was $1.217 per ton, but this was higher than normal. The average ore value was $3.77, and the recovery $2.85 in gold per ton. The mining cost averaged $1.65 and the milling cost $1.27, a total of $2.92 per ton, or a loss of seven cents per ton. The year, however, does not represent normal conditions.

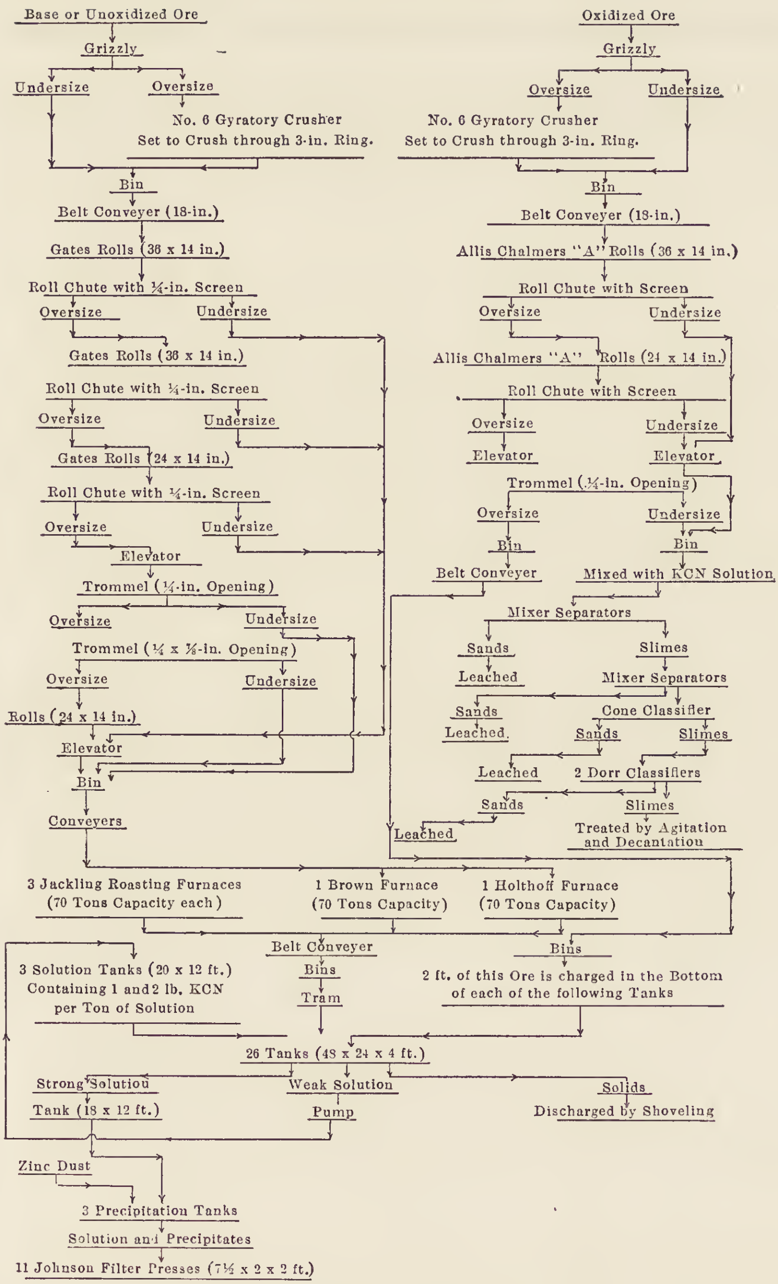
The Goldfield Consolidated Mines Company[4] at Goldfield has made additions to the plant[5] by installing six chilean mills to assist the tube mills in grinding sands from the stamp pulp. The reground sands will be concentrated on 26 additional Deister tables.

The mill of the Boston-Sunshine Gold Mining Company is described by G. W. Wood.[6] The ore, rough crushed by gyratory crushers and rolls, is fed with solution to mixers. The pulp is then separated by Dorr classifiers into sands and slimes. The sands are treated by percolation and the slimes by the Moore vacuum-filter process. The mill is modeled on Black Hills practice.

The Tonopah, Nevada, mills are described by G. E. Wolcott.[7] He discusses the ore treatment at the Belmont, Desert and Montana-Tonopah mills, where practice is still essentially the same as that already described in The Mineral Industry.[8]

---

[1] *Min. and Sci. Press*, XCVIII, 657.
[2] *The Mineral Industry*, XVII, 438.
[3] L. A. Palmer, *Min. and Sci. Press*, XCVIII, 616.
[4] *The Mineral Industry*, XVII, 436.
[5] *Min. and Sci. Press*, XCIX, 825.
[6] *Ibid.*, XCIX, 295.
[7] *Eng. and Min. Journ.*, LXXXVII, 594.
[8] *The Mineral Industry*, XVI, 532.



FLOW SHEET OF CONSOLIDATED MERCUR MILL.

S. F. Shaw discusses[1] present methods at the Standard Consolidated Gold Mining Company's mill at Bodie, California. The ore treatment is practically the same as that described in a previous volume.[2]

S. A. Worcester describes[3] milling in the Cripple Creek district, assigning reasons for the causes of failure and estimating the cost of erection and ore treatment in a 20-ton mill for the low-grade ores of the district. The Golden Cycle mill[4] at Colorado City treated about 50 per cent. of the total ore output of the Cripple Creek district for 1909. Forty per cent. was treated by chlorination and about 10 per cent. by smelting. Approximately, 40,000 tons of ore per month have been shipped for treatment during the year to the various reduction plants. The treatment charges, including freight, on ore carrying up to 0.5 oz. gold per ton have been reduced from $4.50 to $4 per ton. The charges on higher-grade ores remain the same as formerly. In April, the mill of the Independence company began operations, treating monthly about 5000 tons of dump ores averaging $3.60 gold per ton. The method of treatment is as follows: The dump rock, loaded by a power shovel, is coarse-crushed in gyratory crushers and rolls. The ore then passes to two Chilean mills crushing in cyanide solution and the pulp concentrated on tables to remove tellurides and sulphides. The tailings from the tables are classified into sands and slimes, both of which are cyanided. The concentrates are roasted and cyanided. No detailed description of the mill is available. The metallurgical situation at Cripple Creek in reference to the low-grade ores available is discussed in *Mines and Minerals,* May, 1909. It is stated that experiments have shown the feasibility of concentrating the low-grade unoxidized ores, about six into one, saving, approximately, about 65 per cent. of the gold content. The concentrated material is to be shipped to Colorado City for treatment.

The unoxidized ores of the Cambrian formation in the Black Hills, South Dakota, have always given much trouble in treatment by cyanidation, the recovery from the typical blue ore seldom exceeding 40 per cent. Endeavors to treat the unroasted ore by all sorts of modifications of the cyanide process have not succeeded. Some failures to handle the roasted ores successfully by chlorination have aroused a certain prejudice against roasting which, combined with the cost involved (the ores in the main being low-grade, carrying from $4 to $10 gold per ton), has prevented an investigation of the roasting method as applied in a modern way. The problem presented is similar to that of the low-grade unoxi-

[1] *Eng. and Min. Journ.*, LXXXVII, 488.
[2] *The Mineral Industry*, XV, 414.
[3] *Eng. and Min. Journ.*, LXXXVII, 956.
[4] Philip Argall, *Min. and Sci. Press*, C, 36.

dized ores of the Cripple Creek district. B. D. O'Brien[1] has investigated the subject of the Black Hills blue ores experimentally and arrived at the following conclusions: (1) That the gold and silver probably exist in the ore in the form of a complex telluride mineral, since practically all ores examined were found on analysis to contain tellurium, and in some cases selenium, arsenic and antimony. The gold-silver precipitates from cyanide solutions invariably contained appreciable amounts of tellurium and selenium. (2) That very fine grinding and agitation with cyanide solution fails to give any appreciable increased extraction over that resulting from the treatment of ordinary sized material: viz., that through a 20-mesh. (3) That roasting at a rapid rate and with high temperature at first, will leave the gold and silver in such condition as to give low extraction. (4) That the best results are obtained if the ore be roasted at a low heat gradually applied, and not exceeding 1000 deg. C. at the end of the operation. The best size of ore for roasting is 10- to 20-mesh material. (5) That extractions of 90 per cent. and over may be obtained if properly roasted ore is reground in cyanide solution, so that the total product may be treated by slime filtration methods.

Mexico.—The Mexico mill[2] of the El Oro Mining and Railway Company at El Oro, Mexico, is the newest mill in this district, and has a capacity of 280 tons per day. The ore is rough crushed to a maximum size of two inches, in a separate crusher house and then passes via the mill bins to the stamps. Forty 1180-lb. stamps making 102 seven-inch drops per minute, crush the ore through eight-mesh screens. A 0.02 per cent. KCN solution is used as battery water. The stamp duty is seven tons per 24 hours. The pulp flows to classifiers, the overflow from which goes to the cyanide department, while the spigot passes to four 19.5x4-ft. Krupp tube mills running at 31 r.m.p. The discharge from the tube mills passes to classifiers, the overflow from which (90 per cent. passing a 200-mesh screen) goes to the agitation vats. The spigot product passes to a 40.5-ft. tailings wheel, which returns it to the tube mills. There are 12 agitation tanks 34 ft. in diameter and 12 ft. deep. The agitation is effected by revolving paddles aided by transfer of the pulp by centrifugal pumps. A small air jet is used to aid aeration. The pulp is one part solid to three parts of the solution, which contains approximately, 0.04 per cent. KCN. The treatment lasts four days, and there is some settling and decantation of solution between periods of agitation. The pulp passes from the agitating tanks to three Burt filters,[3] the filtered solution from which goes to a Burt clarifier, similar

---

[1] *Mines and Minerals*, XXIX, 427.
[2] C. T. Rice, *Eng. and Min. Journ.*, LXXXVII, 686.
[3] *The Mineral Industry*, XVI, 541.

to a Burt filter. Precipitation of solution is carried on by means of zinc shavings. The cost of treatment is given as follows: milling, \$0.30; cyaniding, \$1.28; water supply, \$0.02; total, \$1.60 per ton. The extraction is: gold, 94-95 per cent.; silver, 83-84 per cent.; total extraction of gold and silver content, 91-92 per cent.

The Cedro mill[1] of the Compañia Minera Las Dos Estrellas is near El Oro. The ore, which is oxidized and contains 10 grams gold and 106 grams silver per metric ton, is crushed by Blake crushers to 1½-in. size and then passes to a 9000-ton storage bin. Challenge feeders deliver the ore to 120 stamps which make 102 six-inch drops per minute. The stamps weigh 1250 lb. and crush through 8-mesh No. 18-wire screens, using 8 tons of 0.1 per cent. KCN solution per ton of ore. The pulp flows to 7½x5-ft. cones, the overflow from which goes to a large 34x34-ft. thickening cone which feeds the slimes agitators, while the spigot product passes to five 24x5-ft. Allis-Chalmers tube mills, making 26 r.p.m., in which ore is used for grinders in place of flint pebbles. The tube-mill discharge is lifted by a tailing wheel back to the cones above the tube mill, when the mill is operating on the all-sliming plan; otherwise it goes to the main system of classifying cones which make the separation into sands and slimes. About 45 per cent. of the pulp is treated as slime and 55 per cent. as sand. At this mill and at the Dos Estrellas mill in the same district the ore was completely slimed for several months, but there was practically no difference in the extraction, so that the old practice of sand and slime treatment was resumed.

The sands are collected in one of 10 receiving vats, each of which is 22x7 ft. The overflow from the vat is returned to the cones by a centrifugal pump. After draining 30 hours the sands are transferred by Blaisdell excavators and conveyers to 12 leaching tanks 36x5.5 ft. and of 130 tons' capacity. The sands are given a treatment of 6½ days. The first treatment is with 48 tons 0.4-per cent. KCN solution, followed by 96 tons of 0.1-per cent. KCN solution. The sand tailings contain 16 per cent. moisture when discharged and assay 1 gram gold and 48 grams silver per metric ton. The extraction is 90 per cent. of the gold and 55 per cent. of the silver content.

The slimes are collected in a large settling cone 34x34 ft., the pulp passing from this cone with a consistency of one part solids to four parts of solution to the agitation tanks. The overflow from the large cone is nearly clear and passes to the precipitation boxes after going through sand filters. The twelve 36x10-ft. agitation tanks are similar to those described for the Mexico mill. In these tanks the equivalent of 100

[1] C. T. Rice, *Eng. and Min. Journ.*, LXXXVII, 686.

grams of lead acetate per ton of ore is added. The strength of the KCN solution is 0.1 per cent. The process is one of agitation succeeded by settling and decantation. The five or six agitations require 16 hours and the total time of treatment is 70 hours. The decanted solution, except the last washes, passes directly to the precipitation boxes. From this set of agitation tanks the pulp flows to six other agitation tanks, 36x20 ft., arranged to act continuously so that the pulp flows from the bottom of one into the bottom of the next, and out of the top of this over the top of the next, and so on. Each tank is provided with a double set of agitator arms. The total time of treatment is 186 hours. From here the pulp passes in part to two Burt filters, and in part to settling tanks, from which the solution is decanted, and the settled slimes containing 40 per cent. moisture discharged to the creek. The decanted solution and that from the Burt filters is pumped to the battery storage tanks without precipitation. The extraction on slimes is 92 per cent. of the gold and 65 per cent. of the silver content.

All solutions before going to the zinc precipitation boxes pass through sand filters. About 3000 tons of solution are precipitated per day. The consumption of chemicals per ton of ore is as follows: KCN, 0.56 kg.; zinc, 0.66 kg.; and lime, 7.6 kg. This mill was built about three years ago and its practice is not as yet finally established.

The Virginia & Mexico mill[1] is at Jalisco. The ore is crushed in three 10x7-in. Blake crushers and passes to 30 stamps, crushing in KCN solution and making 109 drops per minute. The stamp duty is five tons per day through 12-mesh screens. The pulp flows to six Wilfley tables, which act both as concentrators and classifiers. The sands from these pass to two Allis-Chalmers 22x6-ft. tube mills, using silica pebbles from the river as grinders. The slimes go direct to the slime plant. The tube-mill product passes directly to six additional Wilfley tables, the fine sands from which go to the sand plant and the slimes to the slime plant, while the coarse sands are returned to the tube mill by two 54x6-in. Frenier pumps set in tandem. The sands are collected in two 36x6-ft. steel tanks provided with a Butters distributer, and a central overflow for slimes. The drained sands are charged by hand onto a Robins belt conveyer which passes them to six 30x6-ft. leaching tanks. The slimes are raised by two Gould pumps to a 20x20-ft. settling tank, which has a clear overflow that passes to the battery storage tanks. The settled slimes pass to fourteen 22x15-ft. slime tanks, with air agitation and a decanting equipment. From here the slimes go to one 22x12-ft. Butters storage tank with mechanical agitator and aeration and thence to a 50-leaf

[1] Jesse Scobey *Eng. and Min. Journ.*, LXXXVIII, 686.

Butters filter. Solutions are passed through sand filters and precipitated by zinc threads. Electric power is used, generated at the plant by steam. Three hundred horsepower are required. The fuel is wood.

The mill of the Santa Natalie Mining and Milling Company[1] in the Guanajuato district was the first all-slime plant to be erected and operated in Guanajuato. The ore is crushed in Blake crushers and then passes to ten 1050-lb. stamps making 106 drops per minute. The hight of drop is $7\frac{1}{2}$ in. and each stamp crushes five tons of ore per day through a 10-mesh screen. A 0.02-per cent. KCN solution is used as battery water. Forty-five per cent. of the battery pulp passes a 200-mesh screen. The pulp is elevated by an air lift to a cone classifier, the overflow from which, all finer than 200-mesh, passes to the cyanide department, while

CYANIDE PRACTICE IN MEXICAN MILLS.

Name.	Crushing in Solution.	Stamps.	Chile Mills.	Tube Mills.	Sand Concentration.	Slime Concentration.	Mechanical Agitation.	Air Agitation.	Pachuca Tanks.	Decantation Wash.	Vacuum Filtration.	Pressure Filters.	Authority
El Oro	*x*	*x*	......	*x*	......	......	*x*	......	......	*x*	......	*x*	Rhodes.
Dos Estrellas	*x*	*x*	......	*x*	......	......	*x*	......	......	*x*	......	*x*	Rhodes.
Mexico	*x*	*x*	......	*x*	......	......	*x*	......	......	......	......	*x*	Guthrie.
Esperanza	*x*	*x*	*c*	......	*x*	......	......	*x*	......	*x*	......	......	Howard.
San Rafael	*x*	*x*	......	*x*	*x*	......	......	*x*	*x*	......	*x*	......	Empson
San Francisco	*x*	*x*	*d*	......	*x*	......	......	*x*	*x*	......	*x*	......	Grothe.
Loreto (*h*)	*x*	*x*	*x*	*x*	*x*	*x*	*x*	......	......	*x*	*x*	......	Sherrod.
Guerrero (*h*)	*x*	*x*	*x*	*x*	*x*	*x*	*x*	......	......	*x*	*x*	......	Sherrod.
Perigrina	*x*	*x*	......	*x*	*x*	......	*x*	*x*	......	*x*	......	......	Empson.
Pinguico	*x*	*x*	*x*	......	*x*	*x*	......	*x*	......	......	*x*	......	Empson.
Guanajuato Red Co	*x*	*x*	......	*x*	*x*	......	*x*	......	......	*x*	*x*	......	VanLaw
Guanajuato Con.	*x*	*x*	......	......	*x*	......	*x*	......	......	*x*	......	*x*	MacDonald.
La Luz	*a*	*x*	......	*a*	*x*	......	......	*x*	......	*x*	*x*	......	Adams.
La Union	*x*	......	*x*	......	......	*x*	......	*x*	*x*	......	*x*	......	Narvaez.
San Matias	*x*	*x*	......	*x*	*x*	*x*	*x*	*x*	......	*x*	*x*	......	Rhodes.
Natividad	*x*	*x*	......	*x*	*x*	......	......	*x*	*x*	......	*x*	......	Friberger.
Lluvia	*x*	*b*	*e*	*x*	*x*	*x*	*x*	......	......	*x*	......	......	Lamb.
Dolores	*x*	*x*	......	......	......	......	......	......	......	......	......	......	Newcomb.
Chinipas	*x*	*x*	......	......	*x*	......	*x*	......	......	......	*x*	......	Lamb.
Rio Plata	*x*	*x*	*f*	......	*x*	*x*	......	*x*	*x*	......	*x*	......	Lamb.
Veta Colorada	*x*	*x*	......	*x*	......	......	......	*x*	*x*	......	*g*	......	Allen.
Virginia & Mexico	*x*	*x*	......	*x*	*x*	......	......	*x*	......	......	*x*	......	Scobey.
El Bote	*x*	......	*x*	......	......	......	......	*x*	*x*	......	*x*	......	Pattinson.

(*a*) Projected. (*b*) Nissen stamps. (*c*) Huntington mills. (*d*) Boss regrinding. (*e*) Lane mills. (*f*) Pans. (*g*) Ridgeway filter. (*h*) Cia. Minera de Real Del Monte y Pachuca. (*x*) In use at present.

the spigot product goes to a 20x3.5-ft. tube mill. The tube-mill product, 55 per cent. of which passes a 200-mesh screen, goes by gravity to a cone classifier, from which the overflow is sent to the cyanide department while the spigot product is returned to the tube mill by an air lift through a hight of 13 ft. Although this pulp is of the consistency of two parts water to one of sand, no trouble whatever is experienced with the air lift.

[1] Edwin Shapley, *Eng. and Min. Journ.*, LXXXVIII, 68.

The slimes are collected in a tank, the clear overflow from which is returned to the battery storage tanks by an air lift, except when it contains appreciable silver and gold, when it is first passed through zinc precipitation boxes. This tank and the treatment tanks are 20 ft. in diameter and 10 ft. high and have 50-deg. cone bottoms. Each cone has a flange near its apex to which is bolted a 10-in. cross pipe fitting connected in turn with a short length of 10-in. horizontal pipe, long enough to clear the sides of the tank. To the end of this a vertical 10-in. pipe which rises to about a foot above the top of the tank is fitted, by means of a tree. At this point, again by a tee, a short length of horizontal pipe is fitted, discharging back into the tank. Into the bottom of the 10-in. vertical pipe a $\frac{1}{4}$-in. air pipe is tapped. When the pulp is charged into one of these tanks it passes down the vertical pipe and flows into the bottom of the tank, affording a clear overflow. For agitation and aeration air is turned into the $\frac{1}{4}$-in. pipe effecting an air lift, the pulp being continuously drawn into the bottom of the 10-in. pipe and discharged back into the tank over the top. The slime treatment is effected by agitation and decantation in these tanks. The ore contains 15 grams gold and 300 grams silver per ton. The extraction is 87 per cent. of the silver and 98 per cent. of the gold content.

The table[1] on the page opposite gives, in a condensed form, the present practice at 23 Mexican cyanide mills.

Honduras.—The mill of the Honduras Rosario Mining Company at San Juacinto has recently changed its system of ore treatment from pan amalgamation and concentration to the all-sliming cyanide process. The ore is a hard quartz, containing some lead, copper, iron and antimony minerals. The average value of the ore milled is 40.05 oz. silver and 0.467 oz. gold per ton. It passes over grizzlies at the mine, the coarse material being washed and the waste sorted out. The ore is then crushed to one-inch size and with the fines is transported to the mill by a bucket tramway. The washings from the coarse ore are settled and treated as a separate material at the mill. Challenge automatic feeders charge the ore to fifty 750-℔. stamps making 100 six-inch drops per minute and having a duty of two tons per stamp per 24 hours. A 30-mesh screen is used and the ore is crushed in a NaCN solution. From the stamps the pulp is lifted by a 4-in. centrifugal pump to three cone classifiers. The spigot from the cones passes to two tube mills. The overflow passes to two settling vats with a peripheral overflow, the clear solution being lifted by a 3-in. centrifugal pump to the battery storage tank. The tube-mill product is returned to the cones for reclassification. The slime from the settling vats, 90 per cent. of which will

[1] Mark R. Lamb, *Eng. and Min. Journ.*, LXXXVII, 696.

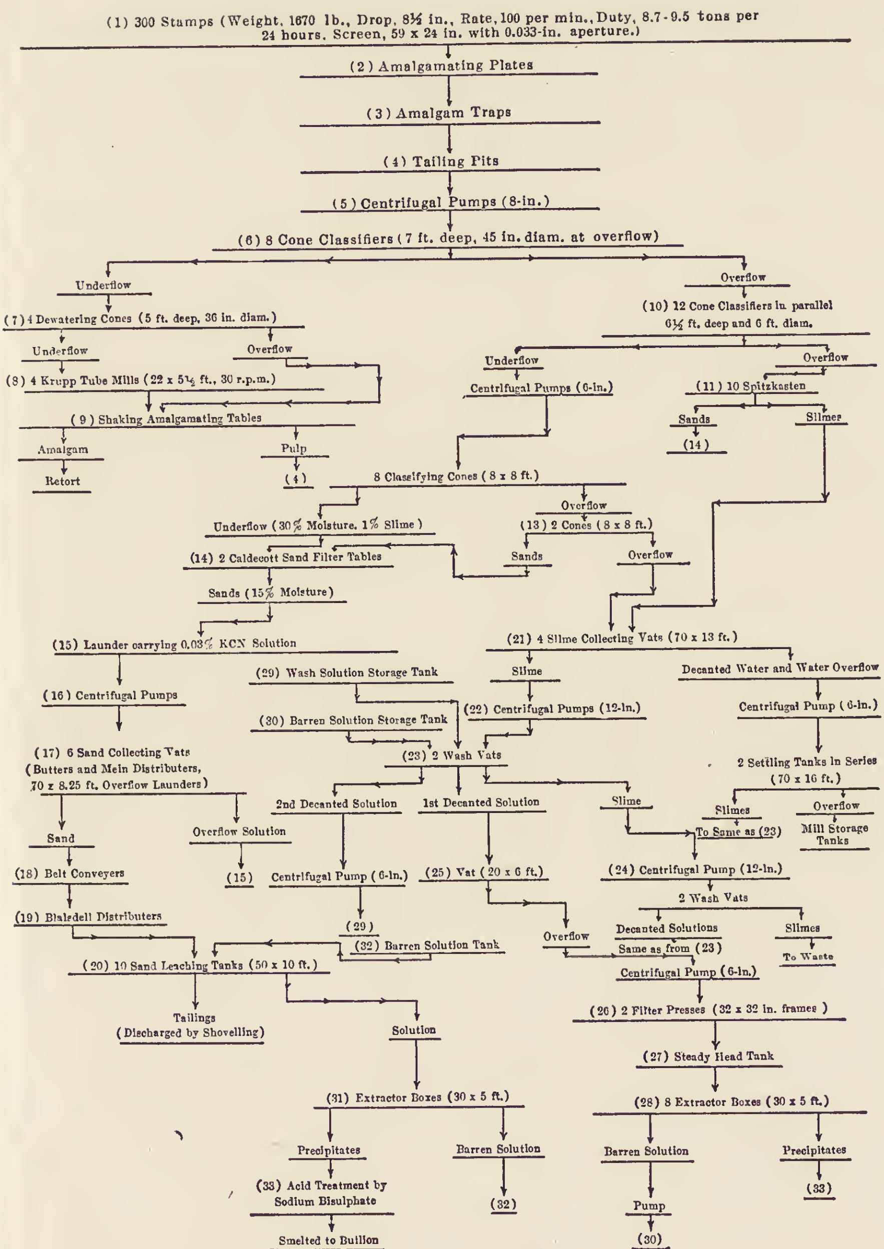
pass a 200-mesh screen, is conveyed by launder to two 90-ton receiving vats, where cyanide is added until the solution contains 0.2 per cent. NaCn, from which it passes to one of seven 50-ton agitation vats. The agitation is accomplished by mechanical stirrers and takes from 60 to 70 hours. Aeration is performed by circulating the pulp two hours a day with a 6-in. centrifugal pump. From the agitating vats the pulp is pumped to the Butters storage vats, from which it is charged by gravity to the 60-leaf Butters filter. A charge of from 18 to 21 tons of slimes requires a treatment of two hours' duration. The filter leaves are subjected to a 2-per cent. HCl wash for one hour every three months. Precipitation of solution which averages 14 oz. Ag and 0.12 oz. Au is carried out by zinc shavings and is practically perfect. The precipitates are shipped each month to New York. The mill tailings for 6 months averaged 3.43 oz. Ag and 0.019 oz. Au. The consumption of cyanide, almost eight pounds per ton of ore, is heavy, due to the antimony and copper contents of the ore. The loss of cyanide in the zinc boxes amounts to $\frac{1}{2}$ lb. NaCN per ton of solution precipitated.

Africa.—The mill of the Simmer Deep Ltd.,[1] at Johannesburg, is one of the plants of the Consolidated Gold Fields of South Africa Ltd. The mill serves both the Simmer Deep mine and Jupiter mine, 200 stamps treating the ore from the first and 100 stamps the ore from the second. There are two mill bins, one of 5460 tons and the other of 2525 tons capacity respectively, the ores from the two mines being kept separate, until discharged as pulp from the amalgamating plates. The amalgam recovered from the two parts of the mill is also kept separate. The tube-mill and cyanide recovery is divided on the basis of the assay of the tailings from the amalgamating plates and the tonnage record. The ore is crushed to $1\frac{3}{4}$-in. size at the crushing stations where waste is sorted out, and conveyed to the mill bins by 35- and 45-ton cars. The accompanying flow sheet gives the mill practice.

France.—The La Bellière mine[2] of the Société des Mines de la Bellière at St. Pierre Montlimart (Maine-et-Loire) produces a complex arsenical gold ore containing some pyrite, chalcopyrite and galena. The ore is treated in a 40-stamp mill with concentrating, roasting and cyanide adjuncts. The pulp first passes over amalgamated plates and is then concentrated on Wilfley tables. The concentrates are roasted for their arsenic contents and are then cyanided with the tailings from the tables. The cyanide treatment is not described in detail.

The Chatelet mine of the Société Anonyme des Mines d'Or du Chatelet

[1] J. E. Thomas, *Journ.*, Chem. Met. and Min. Soc. of S. A., IX, 402.
[2] *Eng. and Min. Journ.*, LXXXVII, 792.



FLOW SHEET OF SIMMER DEEP, LIMITED

at Chambonsur-Voueize in the department of Creuse produces a quartz ore with a small percentage of mispickel and telluride of gold. The ore is crushed dry in ball mills and roasted in Merton furnaces, and then ground in tube mills. The slimes are treated by air agitation and filtered on Ridgeway filters, and the gold precipitated by zinc shavings.

Slime and Sand Treatment

The nature of slime is discussed by H. E. Ashley.[1] All noncrystalline (solid) and noncrystalloid (liquid) matter may be termed colloidal. If suspended in a liquid it is a "sol" and if coagulated a "gel." If crushed material of certain kinds be considered, the coarser particles are crystalloid and are relatively dense and hard compared with the finer matter. Upon and surrounding the crystal grain is an enveloping film of matter in the "gel" form of the colloid condition. It resembles gelatine in its properties, absorbs water and shrinks on drying and cements the grains together. It is less dense and settles more slowly than the crystal grains. If a large excess of pure water is used or a proper proportion of a suitable solvent like ammonia, soda ash, or caustic soda, the "gel" is dissolved and forms a turbid suspension which will not settle clear. This is called the "sol" form. In most cases it is the soluble sodium, potassium or ammonium compound combined in a very large and complex polymerized molecule, of which it forms an exceedingly small part.

If sulphuric acid be added to a "sol" the acid takes away from it the base that made it soluble and the "gel" form of the colloid is precipitated and will settle. If barium chloride or lime is added the reaction is somewhat as follows: 2Na with "sol"$+BaCl_2=$Ba with "gel"$+2NaCl$. The insoluble barium or calcium compound is formed and will settle rapidly. If salt (NaCl) is added, it "salts out" the sol, i.e., when salt comes into the solution the "sol" is thrown out of the solution until a solubility equilibrium is reached. The reason lime has a comparatively weak action in settling slimes is that it increases the OH ions in the liquid, and as these OH ions have the property of causing the clay colloid to assume the "sol" form, there are two opposing effects, viz., to precipitate the "sol" as "gel" due to the action of the lime, and to increase the "sol" owing to the greater number of OH ions formed. The factors which affect the settling of slimes are as follows: (1) Viscosity of the medium. Viscosity is the measure of the internal friction in a fluid. The viscosity of water at 0 deg. C. is taken at 1, then it decreases with rise of temperature so that at 50 deg. C. it is 0.3 and at 80 deg. C. it is 0.2. The more viscous the medium the slower will the slimes settle. In heated water settling is more rapid than in cold water,

[1] *Min. and Sci. Press*, XCVIII, 831; *Ibid.*, XCIX, 289.

and in the same manner, the greater the concentration of slimes the slower the settling. Different colloids differ in viscosity so that certain slimes will settle more rapidly than others. (2) Gravity as contrasted to electrostatic repulsion. In true solutions the size of the dissolved molecules is so small that the electrostatic repulsion is greater than gravitation as regards the individual particles and they are uniformly diffused through the liquid. The "sol" is the first step in aggregation, and while electrostatic repulsion still predominates, gravity will cause the formation of layers of liquid of different densities. The "gel" and the crystal are the amorphous and crystal forms respectively and the opposing effects of gravitation and viscosity largely predominate, but electrostatic repulsion still acts on the finest grains.

H. G. Nichols[1] tentatively offers the following as definitions of slimes; (1) In connection with concentration practice, slime is solid matter in such a fine state of subdivision that the viscosity of the medium in which it is suspended is able to retard the velocity of its settlement by imparting to it a virtual specific gravity less than normal. (2) With relation to cyanide practice; slime expresses a condition of finely divided solid matter by virtue of which a sufficient amount of friction is set up in a liquid surrounding it to reduce the relative mobility of the solid and liquid particles below the economic demands of settlement or percolation.

E. M. Hamilton[2] discusses the question of all-sliming, viz., the grinding of ore sufficiently fine so that it may all be treated by slime filtration methods. He defines slime as material the whole of which will pass a 200-mesh screen. He arrives at the following conclusions: (1) That all-sliming is warranted in but a very small number of cases, and that in most instances better commercial results are obtained by treating the ore as part fine sand and as part slime, inasmuch as the crushing of all material through 200-mesh is very costly. (2) That the treatment of a product containing 20 to 25 per cent. of fine sand coarser than 200-mesh by a method designed only for the fine slime material is bad metallurgical practice as it cannot be expected that the method is equally efficient for both kinds of material. Thus, agitators which will handle slimes, choke up on sands, and the time and strength of solution required for obtaining economic extraction on sands is usually longer and greater than that required for slimes, so that different methods of treatment for the two materials are advisable. (3) In crushing an ore, it is almost invariably found that a certain portion of it will crush comparatively easily to a material finer than 200-mesh, but that a certain portion is reduced to

[1] *Min. and Sci. Press*, XCIX, 252
[2] *Ibid.* XCIX, 255.

this fine state of division with great difficulty. This part of the ore in the system of classification adopted in all-sliming mills, circulates round the milling system for a long time, greatly reducing the capacity of the same. If this material were separated out as fine sand at the proper point and treated as such by leaching, the capacity would be increased and cost of treatment decreased with approximately the same extraction. (4) For success in treating fine sand it is essential to have (a) a clean separation of sand and slime; (b) a thorough disintegration of the sand in transferring from the collecting to the leaching vat; (c) a drying out of the charge in the collecting vat by vaccum, as a precedent to b; (d) the use of a vacuum in the treatment vats for the purpose of aeration.

It is advocated that in place of the usual collecting vat with a peripheral overflow and Butters distributer with unequal discharge arms, vats with a central discharge and a distributer with equal arms reaching to the periphery of the vat be used. The central discharge for a 25-ft. vat is in the bottom of the tank and is two feet in diameter. The distributer deposits the sands against the sides of the vat where they form a bed having a cone-shaped depression sloping toward the center of the vat. As the hight of the sands increases, the discharge is built up with cast-iron rings placed in position with a special tool until the tank is full. The slimes and solution flow over the inclined bed of sand to the central discharge. This method gives very clean sands, practically free from slime even on a feed that has been subject to but little previous classification. The original article contains drawings and a detailed description of the device.

The Pachuca agitation tank[1] when used for the agitation of pulp containing heavy sands and concentrates which would tend to choke up the lower part of the tank and impede circulation may be improved by the addition of circulation pipes. These are vertical pipes extending from a little below the level of pulp in the tank, down the sides to within 6 to 18 in. of the central lift pipe. Usually there are four circulation pipes, the combined area of which should be about one-half the area of the lift pipe. Their function is to supply solution or thin pulp from the top of the tank to the congested portion near the lift pipe.

A continuous agitation of slimes pulp in a series of Pachuca tanks is advocated by Mennell and Grothe.[2] In place of the usual practice of filling the Pachuca agitation tank from the slimes collecting and thickening tank, agitating and aerating for 48 hours or whatever time is requi-

[1] W. M. Brodie, *Eng. and Min. Journ.*, LXXXVII, 695.
[2] *Mex. Min. Journ.*, Feb., 1909, 15.

site, and then discharging to the storage tank ahead of the vacuum filters, it is proposed to install a series of three or four Pachuca tanks in a row, the difference in level between them being just sufficient to cause the pulp to flow from the top of the head tank over the top of the next succeeding one, and so on, until discharged from the top of this to the vacuum filter storage vat. The first Pachuca tank would be constantly charged from a continuous-acting slime-thickening vat, like the Dorr apparatus.[1]

Experiments embodying the above idea have been caried out in miniature Pachuca tanks with the results outlined in the following tables:

RESULTS OF CYANIDATION IN PACHUCA TANKS BY THE INTERMITTENT PROCESS.

Amount of Ore Used. Kilograms.	Amount of Solution. Kilograms.	Time Agitated. Hours.	Strength Cyanide Solution. Per Cent.	Consumption of Cyanide Kg. per Ton.	Heads. Grams Silver Per Ton.	Residues. Grams Silver. Per Ton.	Extraction. Per Cent.
70	100	0	0.39	0	349	....	....
....	....	12	0.26	1.86	....	118	66
....	....	24	0.20	2.71	....	108	69
....	....	36	0.13	3.76	....	98	71.2
....	....	48	0.12	3.86	....	95	72.7

RESULTS OF CYANIDATION IN PACHUCA TANKS BY THE CONTINUOUS SYSTEM.

Amount of Ore Fed Daily. Kilograms.	Amount Sol. Fed Daily. Kilograms.	Tank.	Time of Treatment. Hours.	Strength Cyanide Solution. Per Cent.	Consumption of Cyanide. Kg. per Ton	Heads. Grams Silver Per Ton	Residues. Grams Silver. Per Ton.	Extraction. Per Cent.
70	100	....	0	0.39	0	352	....	....
....	....	1st	12	1.30	1.29	....	146	58
....	....	2nd	24	0.26	1.86	....	122	68
....	....	3rd	36	0.20	2.71	....	101	71.3
....	....	4th	48	0.18	3.00	....	80	77.3

An ordinary overflow from tank to tank was found insufficient, as a concentration of the pulp would take place in the first tank. This was overcome by the use of a radial collector or collecting ring placed a short distance under the surface of the pulp, thus practically sampling the falling particles in each tank, and obtaining a transfer of pulp of average consistency. The table at top of following page shows the screen analysis of the pulp in the four tanks.

The theory of this continuous treatment is as follows: If the tonnage of ore and solution fed continuously into the first tank every 24 hours be equal to the capacity of the tank, then the average time of treatment which the pulp discharging from this tank receives is 12 hours, 50 per cent. receiving less and 50 per cent. receiving more than this time. The pulp issuing from the second tank receives similarly another 12 hours' treatment or a total average treatment of 24 hours. Only 25 per cent. has

[1] *The Mineral Industry*, XVII, 454.

SCREEN ANALYSIS OF PULP SUPPLIED TO PACHUCA TANKS.

Size.	First Tank. Per Cent.	Second Tank. Per Cent.	Third Tank. Per Cent.	Fourth Tank. Per Cent.	Overflow. Per Cent.
Under 100 mesh	0.0	0.0	0.0	0.0	0.0
100 to 120 mesh	16.5	16.7	20.9	14.2	18.3
120 to 150 mesh	5.2	6.8	3.6	11.2	6.6
150 to 200 mesh	8.2	9.5	9.5	7.1	6.6
Over 200 mesh	69.5	66.0	64.3	66.6	67.6
	99.4	99.0	98.3	99.1	99.1

now received less than 24 hours' treatment and likewise 25 per cent. has had more than 24 hours. The pulp issuing from the third tank similarly has received another 12 hours' treatment, or 36 hours in all, and only 12.5 per cent. has now had less than 36 hours' treatment, while 12.5 per cent. has had more than this time.

Upon ordinary ores a battery of three tanks is sufficient to enable the economic extraction to be obtained, for with only 12.5 per cent. of the ore discharging from the third tank with less than the desired or average time of treatment, it is of small practical importance, for this 12.5 per cent. has received sufficient time to enable a fairly good extraction to be obtained from it under any circumstances. This extraction is improved by averaging with it the better extraction obtained from the 12.5 per cent. which has received more than the average time of treatment. However, if a fourth tank be used in the battery, as in most cases will undoubtedly be the practice, the average time of treatment received by the discharging pulp will be 48 hours, and only 6.25 per cent. of it will have received less than this average, and 6.25 per cent. will have received more. If a fifth tank be used, the proportion of the pulp discharging from it with less than the average time of treatment will be only 3.125 per cent., and from a sixth tank 1.5 per cent., and so on.

The advantages claimed for the method are as follows: (1) The avoiding of loss of time in filling and emptying tanks; (2) eliminating the expense of discharging tanks; (3) a reduction of the skilled supervision required; (4) as the final pulp is discharged from the top of the high tank, instead of the bottom as in the intermittent practice, the pulp can go by gravity to the vacuum filter storage tanks, thus saving a certain amount of pumping.

The continuous decantation method of treating slime, finely ground sands and concentrates, has received considerable attention during the year. The modified Usher process and the Nichols process have been described.[1] Andrew F. Crosse[2] outlines a decantation system as fol-

[1] *The Mineral Industry*, XVII, 452-453.
[2] *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 172.

lows: The slime, collected in a suitable manner, is washed with a weak cyanide solution in a conical treatment vat. The latter is provided with an interior conical baffle open at the bottom and reaching about half way down the treatment vat. Inside the vat is a pipe extending from near the bottom of the cone to a foot or two above the surface of the pulp. At the lower end of this pipe a smaller pipe is introduced, through which air is forced, causing a current of thickened pulp to be forced up the tube. The pulp is returned to the conical baffle by a jacket and radial pipes. The clear liquid in the outer portion of the conical vat overflows through a decanting pipe into a zinc box where the gold and silver are deposited. The barren solution is then pumped back to the top of the conical baffle plate by an air lift. The whole mass is kept in continuous circulation, with aeration, the same solution after precipitation acting as a wash. When sufficient extraction has been obtained the slimes are discharged at the bottom of the tank. It is difficult to see where this method would do away with the inherent objections to the decantation process, viz., the loss in soluble gold and in KCN, which is generally admitted by metallurgists to be serious. The method is successfully applied at the Crown Mines, Johannesburg,[1] to the treatment of black sand, a by-product of the battery clean-up, sand filters being placed between the conical vats and the zinc boxes for clarifying the solution.

Ferdinand McCann describes[2] a continuous system of decantation termed a "dilution system," whereby the slimes, after agitation in Pachuca tanks, are thickened in a Dorr slimes thickener, the clear solution overflowing to storage and precipitation vats while the thickened slimes are transferred with a weak or a barren solution to a second thickener, and again, in the same manner, to a third thickener, etc., to be finally discharged. The system seems to offer no advantage over the ordinary decantation method.

C. H. Jay[3] describes a continuous, dewatering, agitating and filtering cyanide process whereby finely crushed ore is agitated in a Pachuca type of tank in the lower part of which is suspended a set of hollow cylindrical canvas filters. The pulp is thickened and charged into the agitation filter tank; suction is created in the filters and the charge dewatered. Cyanide solution is then added, and the charge agitated in the manner usual in the Pachuca tank. When the gold and silver have gone into solution, suction is started in the filters, the solution withdrawn, and cyanide solution added at the top of the tank. This process is continued until sufficient extraction has been obtained, when the with-

[1] Fraser Alexander, *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 174.
[2] *Eng. and Min. Journ.*, LXXXVIII, 688.
[3] *West. Chem. and Met.*, V, 167.

drawn solution is replaced by water, and instead of suction, water is turned on the filters, which are thus freed from their adherent slimes. The tank is then discharged and is ready for a second treatment. An experimental plant has been in operation.

New Filters.—The Oliver filter[1] consists of a rectangular wood or steel tank in which a filter cylinder revolving once every five or six minutes is partly submerged. The slime in the tank is kept at a constant level by an automatic float. The filter drum through which a hollow trunnion passes, is composed of wooden staves mounted on cast-iron spiders. The surface of the cylinder is divided into 24 compartments. Each section is attached to an automatic valve by both a compressed-air pipe and a vacuum pipe, for the connection of compressed air and suction respectively. The outer periphery of the compartments is covered with a specially prepared filter medium in turn covered with light canvas. The entire drum is wrapped with hard steel wire. Against the side of the cylinder and resting on the wires is a flexible steel scraper, designed to assist in the removal of the slime cake. The filters are 11.5 ft. in diameter and 7 to 14 ft. long. When the formation of the cake is commenced a suction, equivalent to 22 to 25 mm. mercury, is applied to the vacuum pipe by means of an automatic valve. This causes the formation of a ¼ to ½-in. slime cake on the submerged part of the filter. As the cake emerges it is dried so as to contain about 35 per cent. moisture. A spray wash is then applied to remove soluble gold and silver from the cake. Just before the cake reaches the scraper the suction is cut off and air at 5-lb. pressure is automatically admitted to the filter. The cake becomes detached and slides down over the scraper into a launder. The removal of the cake is assisted by a water spray. After passing the scraper the suction is immediately restored to the compartment involved and it passes again into the pulp for another charge. The action of the filter is thus continuous. The weight of pulp is nearly uniformly distributed over the filter, and the power required is low. The automatic valve is simple in construction and does not readily get out of order.[2] The drums are submerged for three-fifths of a revolution.

At Minas del Tajo, Rosario, Sinaloa, Mexico, two 11.5x8-ft. filters treat 125 tons of dry slime per day, discharging the slime almost completely free from cyanide and dissolved gold and silver. The loss of cyanide discharged is from 0.1 to 0.3 lb. per ton of dry slime. The slimes going to the filter contain 2.55 oz. silver, of which 1.15 oz. is undissolved, and 0.04 oz. gold, of which 0.01 oz. is undissolved. The residues leaving the

[1] A. H. Martin, *Min. and Sci. Press*, XCIX, 715.
[2] Tweedy and Beals, *Bull.*, A. I. M. E., XXXVIII, Feb., 1910, 149.

filter contain 1.24 oz. silver and 0.011 oz. gold, showing a loss of soluble metal of only 0.09 oz. silver and 0.001 oz. gold. These figures represent the treatment of 11,126 tons of dry slime. The total cost of filtering, including supervision, shop charges, repairs, labor, power, etc., is 16c. per ton of dry slime. There are four Oliver filters in use at the Grass Valley mines, California, and twenty more in other American and Mexican plants.

W. A. Caldecott[1] has successfully installed continuously operating, horizontal filters for dewatering sands, preliminary to charging into leaching tanks for percolation, at the Simmer Deep mill in Johannesburg, S. A. The filter table has an external diameter of 20 ft. and consists of an annular launder 30 in. wide containing a filter cloth resting upon a grating false bottom and forming the filter bed, which has an area of 137.5 sq.ft. The box under the filter cloth is connected by radial pipes to a central hollow spindle in which a vacuum of 3 to 10 in. mercury is maintained.

The sand is charged from a cone classifier and is scraped from the table into a launder by a plow set near the charging point, but distant from it by nearly a revolution of the table, which revolves once in three minutes. The table and connected pumps require 11 h.p. to operate them. Including the centrifugal pump for transferring the sands and added solution to the leaching tanks, 51 h.p. are required. The scraper plough leaves about one inch of sand on the filter. This sand becomes clogged with slime after a time and is then removed by lowering the scraper during one revolution. Two tables handle 2600 tons of sand per 24 hours. The sand charged from the cone contains about 30 per cent. moisture, while the sands discharged from the table contain 12 to 15 per cent. moisture. As the sands are discharged into the launder they are mixed with weak cyanide solution and conveyed to the leaching vats. It is desirable to thoroughly remove slimes from the sands by preliminary classification and to charge the sands from the cone as thick as possible in order to get the maximum capacity from the tables. The device possesses the following advantages: (1) It eliminates the sand collecting vats and makes them available for leaching, increasing the capacity of the plant. (2) It shortens the time of treatment in so far as it practically eliminates the time required for collecting the sands in vats and dewatering them. Solution of gold commences when the sands are discharged from the tables into the launders containing cyanide solution. (3) The tables yield a comparatively dry sand, which is well adapted to treatment and is free from lumps and accretions, so that

[1] *Journ.*, Chem. Met. and Min. Soc. of S. A. X, 46.

a somewhat higher extraction is obtained. (4) It appreciably decreases the cost of sand treatment. (5) In constructing a new plant the installation of sand filters reduces the capital outlay materially by eliminating the cost of many tanks and the cost of their erection.

A. W. Allen describes[1] the operation and necessary connections of a Butters vacuum filter arranged so that the filter tanks fill with wash solution while the residual pulp is being discharged to the next filter compartment, by a top delivery. The practice shortens the total time of the filtering operations, and entails no drying of the slime cake with consequent cracking and imperfect washing which might ensue.

A. Salkinson discusses[2] the effect of warmed cyanide solutions on the results of slime treatment by the decantation process at the Knights' Deep, Simmer East plant. The cyanide solutions used are heated by waste steam from the mill engine in a pipe solution heater. The effect of the heated solutions (75 to 85 deg. F.) was to accelerate slime settlement, increasing the capacity of the plant 10 per cent. The extraction of gold was no greater than with cold solutions.

E. J. Sweetland[3] carried out some experiments, with a filter press, in pressure filtration of Goldfield slimes, and arrived at the following conclusions: (1) That slime will distribute itself over a filter leaf in such a manner that filtration of solution is practically uniform, and that there is little danger of a differential washing of slime cake due to uneven consistency. (2) That in filtering under pressure the point of greatest resistance to the passage of solution is where the slime cake is in contact with the filter medium and that an increase in the thickness of the cake does not increase its resistance proportionately, but at a much lesser rate than that of the increase in thickness. (3) That while the amount of water required to displace solution is a constant, the time of washing with it is a function of the pressure. Thus, in an experiment the same amount of washing, with a given amount of solution, takes 60 min. at 10-lb. pressure and only eight minutes at 60-lb. pressure.

Chemistry of Cyanidation.

Cyanidation of Silver Ores.—Theo. P. Holt[4] has experimented on the solubility of precipitated silver sulphide, and of the silver minerals, argentite, pyrargyrite, pronstite, tetrahedrite, embolite, and native silver in cyanide solution, under varying conditions, and with the addition of certain reagents, such as soluble lead salts, litharge, mercury salts, etc. The results are tabulated in the tables on page 355.

[1] *Eng. and Min. Journ.*, LXXXVII, 1004.
Journ., Chem. Met. and Min. Soc. of S. A., LX, 308.
[3] *Min. and Sci. Press*, XCIX, 853.
[4] *Ibid.* XCVIII, 546; XCIX, 159.

SOLUBILITY OF SILVER SULPHIDE IN CYANIDE SOLUTIONS. (a)

Method of Treatment.	Ag Dissolved, mg.	KCN Consumed, mg.	Ag Dissolved, %
KCN Solution	14.02	....	7
" "	14.42	....	7
" " charged with O_2	40.50	75	19
" " +383mg. $PbC_4H_6O_4$	190.92	271	88
" " +450 mg. $PbC_4H_6O_4$	170.20	256	79
" " +1000 mg. $PbC_4H_6O_4$	130.30	282	60
" " +227 mg. PbO	214.20	318	99
" " +500 mg. PbO	211.10	318	97
" " +227 mg. PbO+200 mg. Sb_2S_3	41.85	....	19
" " +500 mg. CaO+200 mg. Sb_2S_3	4.06	....	2
" " +475 mg. Hg_2Cl_2	198.00	312	92
" " +1800 mg. Hg_2Cl_2	126.30	600	58
" " +1800 mg. Hg_2Cl_2+300 mg. K_4FeCN_6	113.90	622	53
" " +150 mg. $SbCl_3$	140.80	527	68
" " +150 mg. $SbCl_3$+200 mg. Sb_2S_3	90.90	615	42
" " +500 mg. NaCl	33.80	....	16
" " +243 mg. $PbC_4H_6O_4$	185.20	293	85
" " +227 mg. $PbC_4H_6O_4$+227 mg. PbO	185.80	300	86
" " with no oxygen present	11.10	....	5
" " " " " + 383 mg. $PbC_4H_6O_4$	73.94	144	33
" " " " " +383 mg. $PbC_4H_6O_4$	74.40	165	34
" " " " " +383 mg. $PbC_4H_6O_4$+227 mg.	100.70	....	49
" " " " " +227 mg. PbO	18.88	....	9
" " " " " +227 mg. PbO	17.20	....	8
" " " " " +227 mg. PbO + 227 mg. $PbC_4H_6O_4$	127.60	184	59

(a) The above data were obtained by agitating 250 mg. Ag_2S, precipitated from $AgNO_3$ solution, for 17 hours with 150 c.c. of 0.5 per cent. KCN solution and the addition of the chemical stated in the table. The extraction figures are based n solution assays.

SOLUBILITY OF VARIOUS SILVER MINERALS IN CYANIDE SOLUTIONS. (a)

Mineral.	Method of Treatment.	Heads. Ag oz.	Solution. Ag oz.	Extraction. %
Ag_2S	0.5% KCN solution	48.40	23.20	48
"	" " +100 mg. PbO	48.40	42.80	89
	" " +100 mg. PbO+100 mg. Sb_2S_3	48.40	14.22	29
	" " +170 mg. $PbC_4H_6O_4$	48.40	36.84	76
"'	" " +1.02 gm. Hg_2Cl_2+200 mg. K_4FeCN_6	....	29.68	61
"'	" " +510 mg. Hg_2Cl_2	48.40	30.52	63
Ag_3SbS	0.5% KCN solution	47.70	8.57	18
"	" " +100 mg. PbO	47.70	2.44	5
"	" " +170 mg. $PbC_4H_6O_4$	47.70	0.97	2
'	" " +1.02 gm. Hg_2Cl_2+200 mg. K_4FeCN_6	47.70	5.68	12
"	" " +1.02 gm. Hg_2Cl_2	47.70	5.86	12
"	" " +510 mg. Hg_2Cl_2	47.70	6.40	13
$Cu_8Sb_2S_7$	0.5% KCN solution	48.50	6.28	13
"	" " +100 mg. PbO	48.50	1.07	2
"	" " +170 mg. $PbC_4H_6O_4$	48.50	0.59	1
"	" " +1.02 gm. Hg_2Cl_2+200 mg. K_4FeCN_6	48.50	1.85	4
Ag_3AsS_3	0.5% KCN solution	55.51	17.45	31
"	" " +100 mg. PbO	55.51	3.24	6
"	" " +170 mg. $PbC_4H_6O_4$	55.51	2.74	5
"	" " +1.02 gm. Hg_2Cl_2+200 mg. K_4FeCN_6	55.51	9.92	18
Ag_2S	1.75% KCN solution; no lime	73.02	50.46	69
"	" " +1 gm. KOH	73.02	61.85	85
Ag_3SbS_3	0.1% KCN, 15-hour agitation	74.27	4.36	6
"	10.0% " " "	74.27	54.00	73
$Cu_8Sb_2S_7$	0.1% " " "	51.38	2.64	5
"	3.0% " " "	51.38	12.60	25
Ag(ClBr)	0.05% " " "	43.92	41.00	93
Ag_2S	0.05% " " "	44.40	7.74	17
Ag(native)	0.1% " " "	57.35	54.20	95

(a) The pure silver mineral was thoroughly mixed with quartz sand and a little lime and passed through a 100-mesh screen. The endeavor was to obtain samples containing approximately 50 oz. of silver per ton. Fifty grams of material were agitated for about 17 hours with 100 c.c. of KCN solution and the addition of the chemicals stated.

The following conclusions are drawn: (1) The usefulness of lead salts is limited to those ores in which the silver is present as argentite, or in such form that there is danger of silver being precipitated as Ag_2S.[1] (2) In case the silver is present as proustite (Ag_3AsS_3), pyrargyrite ($Ag_3Sb_3S_3$), or tetrahedrite ($Cu_8Sb_2S_7$) the additions of lead salts in the presence of lime would seem to retard, rather than assist, solution. The addition of PbO in the presence of stibnite gives very poor results. (3) No beneficial results are obtained by the addition of mercurous salts to the difficultly soluble silver minerals such as proustite, pyrargyrite, etc. (4) The use of litharge is to be preferred to that of other lead salts. (5) Bromo-cyanogen in the absence of free cyanide is not a solvent for silver minerals, but its addition in small quantities leads in many cases to an increased extraction due to the power of BrCN as an oxidizer. (6) The solubility of the silver minerals in KCN solution in the presence of lime stands in this order: embolite, native silver, argentite, proustite, pyrargyrite, tetrahedrite. (7) In order to obtain an economic extraction from proustite, pyrargyrite and tetrahedrite, it seems necessary to submit them to a chloridizing roast.

D. Mosher[2] states that a copper-ammonia solution containing a sufficient per cent. of KCN acts powerfully on the base silver-sulphide minerals and will dissolve the silver to a greater extent and with less loss of cyanide than would be possible by the use of plain cyanide. He also urges the use of calcium cyanide in this connection in place of the more expensive alkali cyanides. The modified cyanide process is elsewhere described.[3] He discusses the various oxidizing agents which are available for silver ore cyanidation, and their method of application. Chlorine may be cheaply produced by the Townsend electrolytic chlorine cell, with the production of caustic soda as a by-product. If finely crushed ore containing such difficultly soluble silver minerals as proustite and pyrargyrite, be agitated in acid-proof tanks and chlorine gas passed into the mixture, the following reaction will take place for the pyrargyrite: (1) $(Ag_2S_3)Sb_2S_3+12Cl=6AgCl+2SbCl_3+6S$; (2) $2SbCl_3+6NaOH=Sb_2O_3+3H_2O+6NaCl$.

The silver will be converted into chloride, which is readily soluble in cyanide solution, and the acid products formed with the excess chlorine may be neutralized by the caustic soda by-product of the chlorine cells. It is very probable that other complex reactions would take place, giving rise to difficulties which the author of the article has not taken into consideration. Ozonized air is also advocated as an oxidizing agent.[4]

[1] *The Mineral Industry*, XVII, 456.
[2] *Min. and Sci. Press*, XCVIII, 691.
[3] *Eng. and Min. Journ.*, LXXXVII, 814; *Electrochem. and Met. Ind.*, March, 1908.
[4] H. A. Megraw *Eng. and Min. Journ.*, LXXXVIII, 645.

E. M. Hamilton[1] discusses experiments on the cyanidation of manganiferous silver ores. The ore in question was highly oxidized and on treatment with ordinary cyanide solutions containing even up to 5 per cent. KCN, did not yield more than 5 to 15 per cent. of the silver. Almost every known method with oxidizing agents and the addition of the reagents usual in silver ore treatment was tried without result. Reducing agents were then applied preliminary to cyaniding. Sodium sulphide had no effect, but ammonium and sodium hydrosulphide, and hydrogen sulphide gave results. After treating the ore with these reducing solutions, washing with water and then cyaniding, an extraction of 73 per cent. was obtained. The consumption of cyanide, however, increased from ½ ℔. in ordinary cyaniding to 12 and 27 ℔. per ton, and made the method practically useless. A chloridizing roast, followed by cyanidation, gave an extraction of 75 per cent. A preliminary treatment with hydrochloric acid gave an extraction of 94 per cent. Treating the ore with a 5-per cent. solution of sulphurous acid, followed by washing and cyanidation of the residue gave an 84-per cent. extraction of the silver with a cyanide consumption of only 4 ℔. per ton of ore. The experiments tried on the ore covered a very wide range.

General.—S. H. Worrell[2] determined experimentally the reaction of gold dissolving in KCN and bromocyanogen as follows: $2KCN+Au_2+2BrCN=2KAu(CN)_2+Br_2=2AuCnBrKCN$, the potassium aurocyanide forming absorption products with the halogens.

M. W. von Bernewitz[3] discussed the effect of graphite in the ore at some of the Kalgoorlie mines, Australia, on the extraction obtained. The graphite is closely associated with the ore, and during roasting a portion of it escapes oxidation. When the roasted ore is ground in pans the graphite forms a scum on the surface of the pulp and flows to the settlers, and in part to the agitators. Its effect is that some precipitation of gold takes place from the weak cyanide solution used in the settlers and agitators. It is noticed that when graphite is present in the ore the extraction generally drops from two to five per cent., depending on the grade of the ore. No remedy for this condition has been found except to exclude such ore as contains graphite. At some of the mines the graphite is destroyed by more thorough roasting.

W. A. Caldecott[4] found that when lime, obtained by the old method of burning alternate layers of limestone and fuel in kilns, is used for cyanidation that the same contains a certain percentage of unburnt

---

[1] *Journ.* Chem. Met. Soc. of S. A., X, 65; *Min. and Sci. Press*, XCIX, 756.
[2] *Min. and Sci. Press*, XCVIII, 356.
[3] *Ibid* XCIX, 758; *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 23.
[4] *Journ.*, Chem. Met. and Min. Soc. of S. A., IX, 327-400; *Min. and Sci. Press*, XCVIII, 828.

coal which precipitates gold during both the sand and slime treatment. Experiments show that fresh coal has not this precipitating effect, but that half-burned coal has. This is probably due to the fact that liberated hydrocarbon gases are absorbed by the half-burned coal and it is these that form the active precipitating agents.

R. P. Wheelock[1] discusses in detail an interesting process for the regeneration of cyanide solution from the treatment of tailings containing 0.61 per cent. copper in the form of chrysocolla, malachite and chalcocite. In a plant leaching 125 tons of this material per day, the consumption of cyanide was five lb. per ton of ore. After six months operation of the plant the working solutions showed a copper content of 0.45 to 0.50 per cent. The tailings contained small amounts of galena, cerrusite and wulfenite. Experiments showed that the galena and cerrusite were acted on by cyanide, but that wulfenite was not. A test was made on a working scale to regenerate the cyanide in combination with copper. It was assumed that copper was present as $K_2Cu_2Cn_4$. In one test 15 tons of cyanide solution, containing 1.65 lb. KCN, 1.65 lb. $Ca(OH)_2$, and 0.48 per cent. Cu were treated in a tank with 418 lb. commercial sulphuric acid. The mixture was stirred so as to settle the white precipitate formed and then rapidly decanted to a second tank holding five tons of solution containing six lb. of KCN per ton and nearly saturated with $Ca(OH)_2$. This latter solution was made by adding two tons of water which had been pumped through a barrel containing lime to three tons of ordinary solution. The total amount of lime used was 455 lb. The result of the test was a solution titrating 12.2 lb. KCN per ton. This was diluted to proper strength and tried for its solvent power on tailings and found to be satisfactory. The reactions involved, as expressed for the potassium cupro-cyanide, are: (1) $K_2Cu_2Cn_4+H_2SO_4=K_2SO_4+CU_2CN_2+2HCN$; (2) $K_2SO_4+2HCN+Ca(OH)_2=CaSO_4+2KCN+2H_2O$. It will be noted that half the cyanide is contained in the precipitated copper cyanide and half in the solution as HCN gas, and that it is the portion which is regenerated. Not all of the HCN is recoverable, as some escapes from the solution during its decantation. As regards cost, in the test described 182.25 lb. KCN, worth \$37.31, were recovered at a cost of 418 lb. H_2SO_4, and 455 lb. of lime worth \$17.36, a difference of \$19.95. From this figure a small amount should be deducted for labor and power. There are also possibilities of treating the copper cyanide precipitate for its cyanide.

Thomas B. Crowe describes[2] cyanide tests made on Cripple Creek telluride ores, with the use of various reagents, in the endeavor to find a

[1] *Min. and Sci. Press*, XCIX, 814.
[2] *Journ.*, Chem. Met. and Min. Soc. of S. A., IX, 398, 434; *Ibid.*, X, 19, 107, 181; *Min. and Sci. Press*, XCIX, 427.

solvent for the tellurides of gold, both free and encased in sulphide minerals, and avoiding the necessity of roasting. It was found that by fine grinding blanket concentrates from these ores and treating them by agitation with small amounts of ammonium persulphate in solution with KCN, an increased extraction could be obtained. The solutions used contained one lb. of KCN, the equivalent of 0.1, 0.25 and 0.5 lb. of ammonium persulphate (NH_4SO_4), and 10 lb. of lime per ton of ore. The extraction, however, still remained very low. The consumption of cyanide did not increase. Ammonium persulphate mixed with cyanide solution almost completely dissolves pure telluride of gold, calaverite and sylvanite, but does not have this action on the tellurides in the presence of pyrite. The following experiments were also made: (1) A preliminary treatment of the ore with ammonium persulphate followed by a treatment with cyanide solution. (2) A treatment by a solution containing both constituents. (3) A treatment by a solution containing ammonium persulphate, potassium iodide, and potassium cyanide.

The first method requires a strong solution of persulphate to obtain good extraction, and in the second the combined solution must also be strong. This excludes their commercial application. The third method is based on the reaction of persulphate with potassium iodide, liberating iodine which with KCN forms cyanogen iodide. Bromo-cyanogen is formed in the same way. The third method gave good results. It is known that bromo-cyanogen with cyanide gives good results on Cripple Creek tellurides and it is difficult to see where the above methods offer anything superior to the bromo-cyanogen treatment which has not been favorably considered by metallurgists when compared to roasting. The use of cyanogen iodide has been known for a ong time.[1] Its action is slower than that of bromo-cyanogen, and it will withstand decomposition longer, but as it is also more expensive, its commercial application is doubtful.

Wm. McCullen and G. F. Ayers[2] propose to recover the zinc usually wasted in the treatment of cyanide precipitation by sulphuric acid or acid bisulphate by precipitating the same as zinc hydrate by means of an emulsion of magnesium hydrate obtained by mixing water with calcined magnesite. The advantage of magnesia for this purpose is that it does not cause the formation of a partially insoluble sulphate ($CaSO_4$) such as lime does, to adulterate the precipitate of zinc. The process consists of stirring an emulsion of finely ground magnesia with the zinc solution in such proportion as to neutralize the excess 1 to

[1] Gaze, "Practical Cyanide Operations." 1898, p. 10.
[2] *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 87.

3 per cent. H_2SO_4 and precipitate the 2 to 8 per cent. zinc as zinc hydrate. This would be separated by filter presses and reduced to metallic zinc by distillation.

R. F. Coolidge describes[1] white precipitates formed in zinc boxes during precipitation at Kendall, Montana. Precipitate No. 1 had the following analysis: H_2O at 100 deg. C., 5.06 per cent.; loss on ignition, 23.30; ZnO, 37.46; SiO_2, 13.12; Al_2O_3, 5.84; Fe_2O_3, 1.55; CaO, 3.62; MgO, 5.12; SO_3, 4.42; Au, 0.48; Ag, trace. This precipitate forms in zinc boxes when zinc solutions become foul with zinc and other salts, and also in the wash-water (weak solution) boxes where the protective alkalinity and cyanide strength are low. Precipitate No. 2 is found in the acid tank after treatment of the precipitates. Its analysis is as follows: H_2O at 100 deg. C., 2.57 per cent.; loss on ignition, 14.10; ZnO, 2.07; SiO_2, 1.69; Al_2O_3, 2.32; Fe_2O_3, 0.33; CaO, 35.19; MgO, 0.17; SO_3, 39.65; Au, 2.39; Ag, trace. It consists largely of calcium sulphate.

The electrochemistry of the solution of gold in KCN is discussed briefly in the light of Christy's researches on the subject, by J. B. Ekely and A. L. Tatum.[2]

Agitators for cyanide testing are described by G. H. Clevenger[3] and T. S. Lawlor.[4] The first is a mechanical device and the second a miniature Pachuca tank.

Miscellaneous.

Treatment of Concentrates.—J. D. Hubbard describes[5] the treatment of concentrates by percolation at Taracol, Korea. The concentrates are obtained from vanners after crushing by stamps and amalgamation. The sulphides in the concentrates consist of marcasite, 56 per cent.; galena, 36 per cent.; spalerite, 6 per cent.; and arsenopyrite, 2 per cent. The concentrates consist of 30 to 50 per cent. sand and 50 to 70 per cent. sulphides. Sizing tests show the following composition: No. 1. On 50-mesh screen, 16.4 per cent.; on 80-mesh, 18.2; on 100-mesh, 12; on 150-mesh, 18; on 200-mesh, 3.4; through 200-mesh, 31.9. No. 2. On 50-mesh screen, 23.4 per cent.; on 80-mesh, 20.1; on 100-mesh, 19.3; on 150-mesh, 19.1; on 200-mesh, 4.1; through 200-mesh, 13.4.

No. 1 concentrates yield an extraction of 86 per cent. of the gold and No. 2 concentrates 80 per cent. All the product passing a 100-mesh screen gives an extraction of over 90 per cent., but cannot by itself be treated by percolation. It is intended to replace the percolation method by fine grinding and agitation. The percolation process is as

---

[1] *West. Chem. and Met.*, V, 287.
[2] *Ibid.*, V, 19.
[3] *Min. and Sci. Press*, XCVIII, 759.
[4] *Ibid.*, XCIX, 197.
[5] *Min. and Sci. Press*, XCIX, 471.

follows: The concentrates are treated in 18 vats 22x6 ft., fitted in the usual way with filters. A few cars of coarse sands are mixed with the concentrates and then the whole charged by hand. Without the use of sands the charges pack in the vats. Lime is added at the rate of 2½ lb. per ton, giving a protective alkalinity in terms of oxalic acid of between 0.5 and 0.6 per cent. This protective alkalinity was adopted after much experimentation. When the vat is filled, a wash of clean water is run on and allowed to percolate for 24 hours. This carries off all soluble sulphides and removes acidity and leaves the charge alkaline. The wash water is run to waste. Formerly, in place of wash water, weak solution was used, but it caused much trouble in depositing soluble matter in the zinc boxes and its use was discontinued. The wash water is followed by a 0.48 per cent. KCN solution, which percolates for 16 days. This is followed by a weak solution wash for 12 hours and a water wash for 12 hours. During the treatment the charge is twice shoveled from one tank to another. The charge also receives aeration, air being admitted under the filters at certain times. Without aeration there is a large falling off in the extraction. Zinc precipitation is carried on in the usual manner.

A. Grothe discusses[1] the treatment of concentrates obtained in silver cyanidation mills, as suggested by F. C. Brown, of the Waihi Mine, New Zealand. The stamp pulp containing about 10 parts of solution to one of ore passes to a Dorr classifier, the overflow from which goes to a pulp thickener, condensing it to four parts of solution to one of solids. The pulp is then fed to slime tables. The overflow from the classifier should all pass a 150-mesh screen. The coarse part of the pulp from the spigot of the classifier goes to tube mills. The concentrates from the tables are joined to the tube-mill discharge and returned to the classifiers, the object being to keep them in circulation in the mill until they are so fine as to float off by surface tension in the vanner tailings. The vanner tailings pass to a second pulp thickener, which feeds the cyanide agitation vats. The idea is that the concentrates are ground so very finely that they behave exactly as the metals in the ordinary pulp and that the extraction of the gold and silver from them will be accomplished in 24 hours or less, with no reprecipitation of values and a consumption of cyanide proportional to that taken by the ordinary ore.

G. E. Wolcott describes[2] the treatment of concentrates at the North Star and Central mills at Grass Valley, California. The concentrates are made on vanners and are charged into a 20x4½-ft. Abbe tube mill,

---

[1] *Eng. and Min. Journ.*, LXXXVIII, 668.
[2] *Ibid.*, LXXXVII, 440.

crushing in a 0.15 per cent. KCN solution. The pulp from the tube mill passes over amalgamated plates and then to classifiers, the spigot from which is returned to the tube mill, while the overflow passes to tanks, where it is agitated mechanically. The period of agitation is six hours. During the treatment the solution is twice decanted from the agitator and replaced by a new solution. The pulp is finally filtered in an Oliver filter. The concentrates treated contain from $30 to $40 per ton and an extraction of 93 per cent. is made with a KCN consumption of 2½ lb. per ton. The approximate cost of treatment is $3 per ton.

Precipitation.—F. L. Bosqui discusses[1] the effect of iron in the zinc and that of zinc shavings when in contact with the iron precipitation boxes at points unprotected by paint. With much iron in solutions to be precipitated (found in the case of treating old tailings, or when zinc is in contact with unprotected iron during precipitation the zinc thread is rapidly coroded, becomes brittle, breaks into small pieces and is termed "brittle zinc." Bertram Hunt and R. S. Browne discuss[2] the effect of mercury in producing brittle zinc. In treating tailings from pan amalgamation the solutions frequently contain appreciable mercury which readily precipitates, and soon replaces the zinc, but preserves its outward form. This material breaks up readily and can easily be squeezed into a solid mass.. Mercury does not interfere with the precipitation of the gold and silver, but the boxes must be carefully looked after, and should not be repacked until the zinc has practically disappeared. "Short zinc" is that zinc in the boxes at the cleanup, which is not more than three to four inches long. It is objectionable because it cannot be used to repack boxes and its treatment by acid or roasting processes is long and expensive. The cause of short zinc is to be found in nature of the shavings used. When cut on an ordinary zinc lathe in which the screw driving the cutting tool is advanced by a ratchet and pawl device, the speed of the tool is variable, resulting in shavings of unequal thickness which give rise to an undue percentage of short zinc. The best form of lathe is the usual type of machine lathe with constant speed of the cutting tool. This type of lathe, however, is expensive. The short zinc is usually a poor precipitating agent. If possible, it should be packed into the compartments of a separate box, and strong, rich solution run through it, when available, until the zinc has practically disappeared.

Mather Smith discusses[3] the relation between the amount of solution to be precipitated and the amount of zinc. The general practice on the

[1] *Min. and Sci. Press*, XCVIII, 478.
[2] *Ibid.*, XCVIII, 718.
[3] *Journ.*, Chem. Met. and Min. Soc. of S. A., IX, 300, 351.

Rand is to use one cubic foot of zinc per ton of solution in 24 hours. The method for precipitation may be such that with an arrangement in series two tons of solution pass through two cubic feet of zinc, or that with a parallel arrangement each ton passes through a cubic foot of zinc. The final result is the same as regards amount of solution and amount of zinc, but the rate of flow through the zinc in the first case is double that of the second. It is contended that too much zinc is used and that the rate of flow is too high. The boxes could be made of considerably greater cross-sectional area, and with a less depth of zinc, than now constructed. Boxes containing six compartments, each 36x22 in. in cross-section and 24-in. deep to the top of the sieve, all full of zinc, took solution at the rate of 0.78 tons solution per cubic foot of zinc per 24 hours. The zinc was reduced in these boxes by decreasing its depth so that the quantity of solution per cubic foot of zinc was three tons per 24 hours, and the precipitation was not impaired, but improved.

A. J. Clark[1] gives the data on zinc consumption contained in the accompanying table:

ZINC CONSUMPTION OF CYANIDE SOLUTIONS.

Au and Ag Per Ton of Solution. oz.	Ratio Au: Ag.	Zinc Dust Consumed Per oz. Au and Ag Precipitated. lb.	Remarks.
0.02	2: 2	6.60	Homestake, low solution.
0.15	2.2: 1	0.91	Homestake, weak solution.
0.47	1: 4	0.59	Cerro Prieto
0.49	1: 4	0.57	Cerro Prieto
0.70	1: 4	0.42	Cerro Prieto
1.84	1: 19	0.19	Montana, W. J. Sharwood.
3.29	1: 99	0.16	An American mill.

In this connection it should be pointed out that the zinc consumption is a function of the amount of solution precipitated and not of its content in gold and silver.[2]

W. D. Lloyd and E. T. Rand describe[3] a rotary extractor for the precipitation of solutions by means of zinc shavings. There is a certain advantage to be gained by the precipitating agent being in motion during precipitation, as it largely prevents coating and fouling of the zinc. This fouling, which prevents efficient precipitation, is very common after new zinc has been in use for some time and is taken care of in ordinary zinc-box precipitation by washing and dressing the boxes. The

[1] *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 205.
[2] *The Mineral Industry*, XIV, 284.
[3] *Journ.*, Chem. Met. and Min. Soc. of S. A., X, 201.

rotary-extractor device also frees the zinc from hydrogen bubbles which interfere with precipitation by polarizing the zinc. For a description and drawings of the apparatus reference is made to the original paper.

Walter Neal describes[1] the treatment of the gold-silver precipitate at the Dos Estrellas mill, Mexico. During the cleanup the precipitates flow by gravity through launders from the zinc boxes on to a 20-mesh screen, then to a 60-mesh screen and thence to the first of two cement sumps. The short zinc resting on the 20-mesh screen is returned to the head compartment of the zinc boxes, while that on the 60-mesh screen, small in amount, is dried and melted with the following charge, Short zinc, 100 parts; borax, 40 parts; soda, 20 parts; sand, 10 parts; lime, 5 parts. This flux gives a very fluid slag containing 40 per cent. Zn and poor in gold and silver. The metal carries 20 per cent. Zn and is added to the bullion from the main clean-up during resmelting. The main precipitate is pumped from the sumps through a filter press and partly dried by passing air through the press. The press is then discharged into a movable steam-jacketed drying car, run under the press to receive the cakes, and then returned to its place and connected up with a boiler. The next day the cakes contain about 18 per cent. moisture. After this partial drying the car is weighed, and the fluxes spread evenly over the top of the precipitate without mixing, and the car run to the furnace. The mixture is then shoveled into No. 400 Dixon graphite crucibles, each holding 87 kg. of precipitate and flux. The precipitate yields 60 to 80 per cent. bullion. The furnace at the Dos Estrellas mill uses coke as fuel, but those at the El Oro and Mexico mills burn oil. The charge is made up as follows: Precipitate, 100 parts; borax, 15 parts; sand, 4 parts; sodium bicarbonate, 8 parts; and scrap wrought iron in excess. After fusion the upper portion of the molten mass in the crucible is poured into a conical mold with a tap hole stopped with clay, about two inches above the apex. The lower portion is poured into ingot molds. When a slag shell about ½ in. in thickness has formed in the tapping mold the clay plug is removed and the core of slag and the bullion button allowed to flow into another mold. A sample of this slag is taken and granulated in water. The slag shells from the tapping molds and the slag from the ingot molds are remelted and again poured into tapping molds and tapped. The cores are sacked and shipped at intervals to a smelter. The slabs of bullion from the ingot molds, together with the buttons from the tapping molds and the bullion from the short zinc are remelted and cast into molds, a sample being taken during pouring. No attempt at refining is made.

[1] *Min and Sci. Press* XCVIII, 327.

Arthur Yates describes[1] a tilting furnace of the Faber du Faur type used for smelting cyanide precipitates at the Redjang Lebong gold and silver mine in Sumatra. The dimensions of the retorts used are: Diameter of mouth, 6.5 in.; greatest diameter, 13.75 in.; bottom diameter, 9.5 in.; length, 30 in. Each retort holds 150 to 200 lb. of precipitate and is placed in the furnace at an angle of 30 deg. The furnace is fired with oil fed by two Billow atomizers. The consumption of fuel is small, one gallon of oil sufficing for the smelting of 12.47 lb. of roasted precipitate. With oil smelting the time required to reduce 2.5 tons of precipitate is 60 hours as against 140 hours when using coke, and the saving in both labor and fuel is considerable.

Progress in Gold Milling in 1909.

By Robert H. Richards and Charles E. Locke.

Design and Construction of Stamp Batteries.

Weight of Stamps.[2]—The present tendency towards increased weight of stamps is due to the increased depth of the mines. At the deep levels the ore is found to be harder and firmer, with fewer seams and cleavage planes. Preliminary breaking to at least 1-in. size assists towards the high capacity of the modern heavy stamps. The weight of a stamp must be so adjusted that the resistance of the rock beneath it shall be great enough to prevent the shoe and the die from unnecessary fracture.

Heavy Stamps.[3]—The new City Deep mill in South Africa will contain 200 stamps of 2000 lb. each, crushing coarse. It is expected that the duty will reach 11 tons per stamp per day. Tube-mills will be used for fine grinding. One novelty of this mill is an arrangement for supporting the cam shaft alongside of each cam for the purpose of reducing the breakage of shafts. Instead of the usual wooden battery posts, concrete piers, 7 ft. high, 14 in. wide, 6 ft. broad at the base, and 4 ft. at the top, are used. Each pier is surmounted by a timber 12 in. thick, and on each timber rests a solid steel casting which is bolted to the pier through the timber. On the castings are placed the usual guide timbers and also a girder of cast steel on which are set the intermediate bearings, 5 in. long, between the cams. The bosses are 46 in. long, 9½ in. diameter, and together with the shoe form a total length of 60 in. They project considerably above the top of the mortar box, and wooden guides to receive them are fitted into the top of the box.

Stamp Mills as Coarse Crushers.[4]—The result of experiment in South Africa indicates that crushing by stamps through a screen with 9 meshes

---

[1] *Journ.*, Chem. Met. and Min. Soc. of S. A., IX, 429; X, 144.
[2] M. Jones. *Min. and Sci. Press*, XCVII, 718.
[3] *Min. Mag.*, I, 323. From *South African Min. Journ.*
[4] *Eng. and Min. Journ.*, LXXXVIII, 1231.

to the square inch, followed by final reduction in tube-mills, is a working arrangement which represents the limit of economy with machines now in use. A capacity of 15 tons per stamp per day has been obtained by this method with stamps weighing not over 1400 lb. The advantage of this arrangement is that it cuts down the capital expenditure per mill. Favorable opinion is also expressed on the arrangement of long heads and short stems as adopted at the new City Deep mill, also on the open-front mortar box, which allows easier access to the stamps. Any loss of strength through the removal of the front of the mortar box does not seem important.

Design of Cams.[1]—The important points in cam design are: (1) To use only the best material, so as to get the necessary strength without increasing the weight and hub dimensions. (2) To proportion the length of the cam to the desired drop. (3) To have the vertical line intersecting the point of contact of the cam and tappet tangent to the inscribed circle of the cam. As an example of the effect of long cam and short drop, a 9½-in. cam, when used for a 6-in. drop at 110 drops per min., strikes a blow on the tappet at a velocity of 90 ft. per min., thereby increasing the noise and the breakage. Crystallization of the cam shafts often results from improper design of cam. The greatest strain comes upon a shaft at the moment of starting the stamp. The use of adjustable cams, which require little holes bored in the cam shaft, is often a cause of crystallization. In one case the cams were so improperly designed that even the foundation bolts of the posts were affected. As material for cam shafts, wrought iron is to be preferred, owing to its softness.

Construction and Operation of Stamp Mills in Rhodesia.[2]—Stamp duty is largely affected by the ability of the stamp to expel the crushed material through the screen; therefore a high capacity requires the largest possible area of screen discharge. In stamps, two vibrations are set up, one due to the blow of the cam on the tappet, the other due to the blow of the shoe on the die. The former is more harmful as it extends to the various parts of the frame, while the latter is taken up by the mortar and mortar blocks. In the present form of frames, the weakest point is in the stepping of the battery post, and it is here that vibration is likely to make itself first evident. With concrete mortar blocks, this difficulty can be remedied by supporting the battery post directly from the solid concrete. The most important bolts in the mill are those holding down the mortar and those which anchor the battery posts to the

---

[1] M. R. Lamb, *Eng. and Min. Journ.*, LXXXVIII, 66.
[2] G. H. Fison. *Min. Journ.*, LXXXVI, 297. Abstracted in *Eng. and Min. Journ.*, LXXXVIII, 1131; *Min. Sci.*, LX 469.

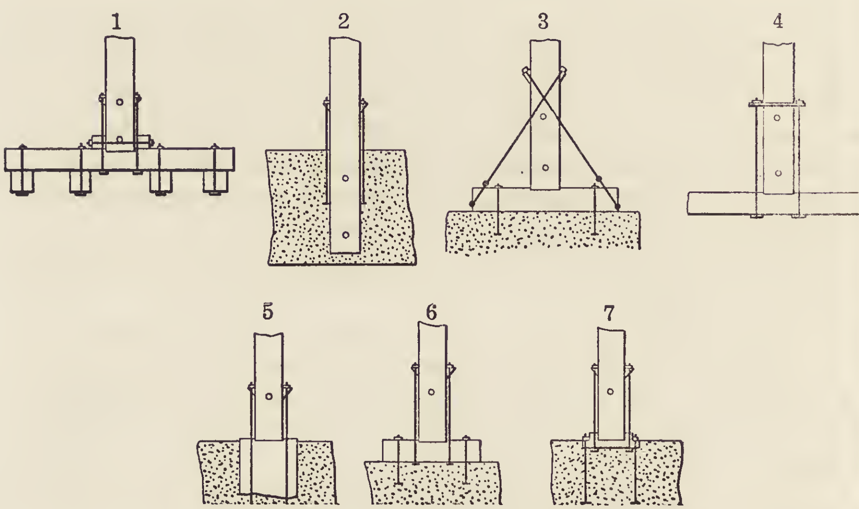
cross sills. These bolts should be so arranged that they can be readily tightened. In some cases, a bolt in two parts, hooked together at the middle, will be found advantageous, especially where the thread becomes worn or stripped on one end, in which case that half may be unhooked and a new half put in. To keep stamp stems in permanent alinement it is well to have center marks on the battery post so that by no possibility can the stems gradually move out of place without being noticed.

To increase the screen capacity, the author believes that we should go back to the double discharge mortar. For high capacity, mortars are made narrow and the front opening is cut down low, which is an advantage in regulating the hight of discharge by chuck blocks. In a mortar with a high front, it is necessary to raise the dies in order to decrease the hight of discharge. Mortar liners, if properly designed, may be easily renewed within a very short time. Hight of discharge should be just short enough to avoid banking of sands against the lower edge of the screen. Dies should be turned once in about two weeks, in order to equalize the wear. The best speed is 95 to 105 drops per min., with a corresponding drop of from 8½ to 6 in. For guides, hard wood is best, but cast iron is coming into favor. The Ralok iron guide has annular grooves on its inside surface as receptacles for the lubricant, which consists of four parts of soft soap to one of graphite. For plates, plain copper is preferred to silver-plated copper, as being more sensitive and absorbent. They have the disadvantage of being a little difficult to start, but this may be overcome by the use of silver amalgam for the first dressing. The use of cyanide in dressing is to be condemned. Increased temperature of water, if maintained constant at about 80 deg. F., is conducive to good amalgamation.

Economies in Stamp Design.[1]—In this article the author discusses some of the details of a stamp mill which make for long life, minimum repairs and efficient running. Some of the essential points are as follows: (1) Stability, or lack of vibration in all parts, especially in the mortar blocks, the battery posts, the amalgamation plate and the ore bin. To mount a rock breaker on the ore bin is bad practice. (2) Attention to details and the use of small units. The breakage of a cam shaft driving five stamps is far less serious than of one driving 10 or 20 stamps. A cam-shaft pulley for every five stamps is better than one pulley for 10 stamps. (3) A proper procedure for setting of tappets. It is not necessary to hang up all five stamps to reset the tappet on one stamp. The method, used by some mill men, of slightly loosening the keys and allowing the cams to shift the tappet on the stem, is poor

[1] A. Del Mar. *Min. Wld*, XXXI, 1015.

practice, for it jams the gib into the stem. A better plan is to knock out the keys and let the stem down by chain blocks, or better still, to clamp a collar the right distance above and let the stem fall until the collar rests on the tappet. For heavy stamps the three-key tappet is preferable. The key seat should be straight and not contracted. (4) A solid foundation of concrete is admittedly better than wood for mortar blocks. The question of wood as compared with steel for battery posts is still unsettled. In either case, however, absolute stability is essential to avoid a broken cam shaft. Various methods of anchoring the battery posts are shown in the figures. Number 1 is the usual form for



METHODS OF ANCHORING BATTERY POSTS.

wooden mortar blocks. For concrete mortar blocks Nos. 2 to 7 may be used. No. 2 will last for years. No. 5 allows the use of a rubber or lead joint where the post rests on concrete. No. 6 is not good. No. 7 with a cast-iron socket has been successfully used. No. 3 has a tendency to break the long rods. No 4 shows only the method of holding down the battery posts; it is not recommended. The bolts in all the foregoing should be readily accessible for tightening in case they work loose. (5) The use of openings to allow access of air under the feeder and amalgamating floors. These should be high enough so that a man can readily enter to inspect all the parts. This space should be kept dry to prolong the life of the wood. Wooden battery foundations if treated with a good preservative, placed in an airy cellar, and with a thin layer of cement next to the mortar block, extending above the water line, will last as long as most mines. (6) The use of a special collar on the feed stem instead of the regular tappet to operate the feeder. (7) Proper placing of the mortar on its concrete bed. A mortar with a planed bottom may be set directly, but if the bottom is rough a sheet of lead or of rubber belting should be used. (8) Movable tables for the amalgamation plates. (9) The selection of a guide with plenty of bearing surface so that longer life may be obtained and no difficulty will occur from heating. Iron guides have come to stay, and a guide 12 in. long is far superior to one 4 or 5 in. long. (10) Constant inspection to keep nuts tight, to replace broken bolts, and to remove dirt, is a matter which is frequently overlooked.

Operation of Stamp Mills.

Practical Helps.[1]—One important help to stamp-mill capacity is continuous running. Shut-downs for keeping the plates in good condition to catch the gold, for the regular clean-up, and for changing shoes and dies are unavoidable, but other stoppages may be obviated by having the repairs well made, by keeping duplicate parts on hand and by making repairs as far as possible at the time of the clean-up.

Suggestions for increasing the total running time are as follows: (1) Sectional wooden guides in a cast-iron frame, instead of iron guides. The latter wear the stems and not only have to be replaced themselves, but cause loss of time in setting tappets on the worn stems. (2) The Knight wheel on feeders instead of the usual friction wheel with pawls. The latter introduces irregularity which may result in the battery's running dry and breaking a stem. (3) Self-tightening cams and self-tightening cam-shaft pulley will avoid slipping of these two parts. (4) Shims inside the tappet on a worn stem will make the tappet hold without slipping. (5) Careful alinement of the cam shaft will prevent the loosening of its collars by vibration.

Breakage of stems may be due to uneven wear of shoes and dies, to tools fallen into the mortar, or to a stamp allowed to drop on a bare die. Broken stems should be annealed before they are used again, to remove crystallization. The quickest way to change a stem, if the top end is good, is to take it out of the guides and turn it end for end. In case a new stem has to be installed, the battery is hung up, the boss taken out of the mortar, the shoe forced off and wedged into an extra boss. The boss with the shoe on it is then returned to the mortar, the tappet approximately set, the stem inserted in the boss and the shoe pounded on. The operation will take two men half an hour.

Bosses will come off under the blows of the cam upon the tappet when the drop is too rapid, when a long cam is used for a short drop, or

[1] A. Del Mar. *Eng. and Min. Journ.*, LXXXVIII, 548.

when there is too much play in the guides and adjacent bosses strike one another. Steel bosses are preferable to cast iron. Shoes come off from too much play in the guides, from too much ore in the mortar, or from the pounding of the shoe on the die. If the shoe shank appears slippery it may be roughened by a chisel and only hard-wood wedges used. Finally, proper treatment of the mill men will go a long way towards reducing idle hours. The 12-hour shift, 365 days per year, will cause almost any man to become negligent.

Development of Heavy Stamps.[1]—The history of ore crushing by gravity stamps shows a progressive increase in their weight and in corresponding efficiency. The best practice on the Rand in 1889 was the Du Prez mill, which had 20 stamps of 900 ℔. each, making 90 drops of 7 in. per min. The stamp duty was about 3 tons per 24 hours through a 30-mesh screen. Ten years later several installations of 1250-℔. stamps had been made on the Rand. In December, 1902, the Mt. Morgan Gold Mining Company installed 30 stamps of 1500 ℔. each, and the Millionaire Gold Mining Company a mill of five stamps of 1750 ℔. each. In 1907 only a few stamps on the Rand weighed over 1250 pounds.

TYPICAL TESTS WITH STAMP MILL.

	Single-Discharge Mortar Ordinary Mill Feed.	Single-Discharge Mortar Ore from Rolls Set at 0.5 in.	Double-Discharge Mortar Ordinary Mill Feed.
Running weight of stamp, ℔.	1343	1342	1356
Set hight of drop, in.	7.5	7.5	7.5
Drops per minute	98	98	98
Duty per stamp per 24 working hours, tons	5.85	5.68	5.81
Hight of discharge, in.	2.75	Level	3.75
Screen aperture, in.	0.024	0.024	0.024
Tons water per tons ore	7.67	8.35	10.70
Per cent. of screen pulp above 0.01-in. size	29.00	27.50	26.00
Per cent. of feed above 1⅜-in.	54.8	1.1	49.9
Per cent. of feed between 1⅜ and ¾-in.	14.3	19.3	16.3
Per cent. of feed below ¾-in.	30.9	79.6	33.8

The author made an extensive series of experiments, which cannot be described here in detail. Some of his conclusions are as follows: Fine breaking before stamp milling does not increase capacity. Double mortar discharge shows no increased capacity over single discharge, and the former has the disadvantage of requiring more water. For example, the average stamp duty on ordinary mill feed for six pairs of parallel trials was 5.82 tons with a single-discharge mortar. The average stamp duty for four pairs of parallel trials on the product from rolls set at ½ in. was 5.64 tons with double-discharge and 5.78 tons with single-dis-

[1] W. A. Caldecott. *I. M. M. Bull.*, 59, Aug. 12, 1909; *Can. Min. Journ.*, XXX, 588; *Eng. and Min. Journ.*, LXXXVIII, 594, 1157; *Journ.* Chem. Met. and Min. Soc. of South Africa, X, 108, 178, 215; *Min. Sci.*, LX, 272; *Min. Wld.*, XXXI, 543; *Min. Journ.*, LXXXVI, 293.

charge mortar. An example of the form in which the data were compiled is given in the table on page 370.

To increase stamp capacity, the stamp must strike a heavier blow. Helical springs placed around the stem above the tappet were tried, but were found objectionable on account of noise and breakage of springs, which led to the conclusion that the best solution of the problem lay in increasing the weight of the stamp. The accompanying table illustrates this point.

INCREASED DUTY FROM HEAVIER STAMPS.

Apertures per Sq. In. in Mortar Screen	Running Weight of Stamps, lb.	Set Hight of Drop Inches.	Hight of Discharge Inches.	Tons Water per Ton Ore.	Tons Ore Crushed per Stamp per 24 Working Hours.	Over 0.01-In. Size in Screen Pulp Per Cent.
981 (0.021 in.)......	1196	8	3	5.8	5.88	22.63
981 (0.021 in.)......	1279	8	3	5.8	6.58	22.23
981 (0.021 in.)......	1531	8	3	5.7	6.74	20.86
1512 (0.016 in.)......	1216	8	11	5.40	4.26	5.16
1512 (0.016 in.)......	1288	8	11	5.30	4.29	4.91
1512 (0.016 in.)......	1293	8	11	5.43	4.55	9.49
1512 (0.016 in.)......	1337	8	11	6.27	4.96	6.66
1512 (0.016 in.)......	1562	8	11	5.05	5.17	....
1512 (0.016 in.)......	1605	8	11	6.30	6.02	11.66

The result of the test was to recommend that the next 360 stamps erected by the Consolidated Goldfields Company should have a weight of 1550 lb. Other companies followed this same policy on the Rand and stamp duties of 8 tons are as common now as was 4 tons a few years ago. In the United States and Mexico these heavy stamps have not yet appeared to any great extent. In the Simmer Deep and Jupiter joint mill, the shoe weighs 285 lb.; boss, 410 lb.; stem, 723 lb.; tappet, 252 lb.; total, 1670 lb. A summary of actual mill work by heavy stamps is given in the table on page 372.

Another series of tests showed that the cast-iron anvil block between the mortar and the concrete mortar block is of no advantage in increasing the efficiency of the stamp, and that the concrete is not injured by the direct contact of the mortar.

Discussing the result of his tests, the author concludes that for greatest efficiency the stamp should be used as an impact machine and that the maximum effect is obtained when a particle of ore is caught in contact with the die below and the shoe above. In case, however, the layer of ore upon the die is several grains deep, then the work of the stamp is consumed in moving these particles which, instead of being crushed by impact, are merely worn away by abrasion. This line of reasoning shows why the efficiency of the stamps decreases rapidly with fineness of crushing; also why breaking small before stamping is of little help.

	Luipaards Vlei.	Simmer & Jack East.	
	August, 1908	May, 1907	January, 1909
Tonnage milled during month	18,807	35,500	29,600
Number of stamps	60	250	130
New weight of stamps, lb.	1629 (with 18½-ft. stem)	200 of 1550 50 of 1350	1550
Running weight of stamps, lb.	1520	200 of 1450 50 of 1250	80 of 1450 50 of 1550 (with compensating weights)
Average drops per minute and set hight of drop, inches	98.6 at 8½	96 at 8	96 at 8
Duty per stamp per 24 working hours, tons	9.667	5.006	8.333
Hight of discharge, inches	4	9	3½
Aperture of mortar screen, inches	0.056 and 0.046	0.016 and 0.017	0.057 and 0.035
Tons water per ton ore	8	8	6.46
Percentage of screen pulp over 0.01 inches	43.7	10.92	1.61 (final pulp)
Cost of crushing per ton of ore:			
Stamps	1 *s.* 3.879 *d.*	1 *s.* 10.424 *d.*	1 *s.* 3.672 *d.*
Tube-Mills	0 " 6.215 "	....	0 " 7.070 "
Total	1 " 10.094 "	1 *s.* 10.424 *d.*	1 " 10.742 "

The maximum size of stamp feed varies with the kind of ore and with the stamp. With unweathered "banket" ore the author thinks that 1¾ in. is permissible. To maintain the original weight of the stamp, as the shoes wear down, compensating weights of some form are now quite common. The most convenient form is that of split cast-iron discs 4 in. high, weighing 50 or 60 lb. each, which are clamped on the stem by two bolts, either above or below the tappet.

Regarding the area of shoe and die, theory indicates that large areas are not needed for hard ores, while for soft ore a lower, quicker drop can be used, even though the stamps are heavy. The proper adjustment is to have a large enough area so that an excessive amount of ore on the die is not needed to prevent shock. In order to use gravity stamps to maximum advantage it is necessary that uniform speed be maintained, thus allowing the maximum speed and hight of drop without fear of having the cam strike the tappet before the descent of the stamp is finished. Furthermore, with heavy stamps, only five stamps should be put on one cam shaft instead of the usual ten or fifteen.

Gravity stamps are still the standard machine. The Holman pneumatic stamp is having a trial at the New Kleinfontein mill. It is evident that the crushing capacity of the modern mill depends upon many other factors than the mere number of stamps, such as the relative proportion of stamps to tube-mills, the actual running weight of the stamps, the ratio of water fed, the hight of discharge, the hight and number of drops per minute, the screening used, and the maintenance of "concert pitch" in the mill engine.

The advantages of heavy stamps, as compared with lighter ones, may be briefly stated as follows: (1) Reduction of the initial capital expenditure in erecting, say, 200 stamps of 1750 lb. with accessories, in place of 280 stamps of 1250 lb. each; (2) reduction in size of mill building, almost proportionate to the less number of stamps; (3) 30 per cent. less shafting, belts and other moving parts to maintain; (4) 30 per cent. less labor required for dressing plates, lubricating moving parts, changing screens, and other work incidental to milling operations.

Mr. Caldecott's paper has given rise to considerable discussion, and some evidence has been produced that his conclusions are perhaps a little too broad. For example, in other cases, possibly under slightly different conditions, the feeding of finer product to stamps resulted in increased capacity. Altogether it does not appear that we are all converted to the use of heavy stamps.

Salt Water in Stamp Mills.[1]—At the Alaska Treadwell mine it is necessary to use salt water in the mortars during the winter months, when the fresh water supply is frozen. It is found that this water corrodes the iron and shortens the life of the mortars to an appreciable degree. The water is not heated, as it was found by experience that tepid water softens the amalgam. The corrosive effect of salt water is explainable on the theory of electrolysis, which is especially active if there is a little copper in the ore.

At a cyanide plant on Cedros island, off Lower California, salt water was used some years ago and no difficulties were encountered. In Western Australia, mills formerly used brackish mine water, which, in some cases, was almost saturated with salts. At the Queensland Menzies mill the water contained 17 per cent., and at Kalgoorlie it contained 10 to 15 per cent. salts; sea water averages 3½ per cent. salts. This brackish water did not apparently injure the screens of the stamp mill, although it did accelerate rust and impede the settling of slime. At the Lake View Consols mine this settled slime caused trouble by choking of the filter cloths.

At the Alaska Treadwell the vanner rolls were found to corrode badly from the salt water and wooden rolls were substituted. This company uses a process for sweating the plates periodically. A wooden cover is laid over the plate leaving a space of 1½ in. between it and the plate. The sides are stuffed with burlap so as to make a closed chamber and live steam is turned in for about 20 min. under a pressure of from 35 to 65 lb. This treatment softens the amalgam so that it has about the consistency of Swiss cheese and is easily scraped off. The temperature is sufficient to volatilize some of the mercury.

---

[1] T. A. Rickard. *Min. and Sci. Press*, XCVIII, 860.

Amalgamation.

Dressing Battery Plates.[1]—A new system of plate dressing invented by E. H. Martin, the battery manager of the Langlaagte Estate, Rand (S. Africa), allows the amalgamation plates to be dressed without hanging up the stamps. This is accomplished by placing a board across the head of the amalgamating table, and thus running the pulp over the back of a plate into a launder, which runs beneath the plate. The pulp is diverted, so that, instead of running into the main tube-mill launder, it runs over a separate amalgamation table, which is kept specially for this purpose. Ordinarily a strip of wood, ½ in. to 1 in. thick, prevents the pulp from running over the back end of the plate. When the board is put in place the pulp is dammed back, and runs over this strip of wood. The necessary alteration in the tables costs $15 to $17.50 per table, including the necessary labor and materials. The change is accomplished by taking up the plate and relaying it on 3x9-in. timbers, leaving a 4½x3-in. launder under the plate.

Scaling and Sweating Copper Plates.[2]—In February, 1908, at the Evançon mill, north Italy, two outside copper plates, each 12x5 ft., had the hard amalgam of 50 months removed by scaling and sweating. During this period the 10-stamp mill had treated 33,000 tons of quartz averaging 11.74 dwt. of gold and 1.5 dwt. of silver per ton. An average amalgam recovery was 10.94 dwt. of gold and 1.40 dwt. of silver. The plates originally were coated with 1 oz. of silver per sq.ft. Before removing the plates for scaling they were thoroughly rubbed, producing 17 oz. of stiff, pasty amalgam which is not included in the return from scaling. This scaling operation was performed by placing the plates upon low trestles and tapping them sharply on the under side with a wooden mallet so as to crack and loosen the skin of hard amalgam. This yielded 675.16 oz. of clean , dry amalgam. Next the plates were slightly heated over a fire and scraped with steel scrapers, producing 166.12 oz. of amalgam. The total amalgam, 841.28 oz., yielded a retort residue of 331.25 oz., which melted down to 327.93 oz. of bullion having a fineness of 834 in gold and 134 in silver. The average fineness of the mill amalgam during 50 months had been 875 in gold and 115 in silver. The plates, after sweating and scraping, were shipped to London where they were melted and assayed, yielding 55.53 oz. of gold and 5.30 oz. of silver per ton. Summarizing, the two plates yielded:

By sweating and scaling, 273.49 oz. fine gold, 43.28 oz. silver.

By melting, 15.372 oz. fine gold, 1.467 oz. silver.

---

[1] *Aust. Min. Stand.*, July 21, 1909, p. 57. Abstracted in *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 187.

[2] S. F. Goddard, *Trans.* I. M. M., XVIII, 495. Abstracted in *Min. and Sci. Press*, XCIX, 368; *Min. Wld.*, XXXI, 232. *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 151.

Samples of the plate cut from the under side showed no absorption of gold. Samples from the upper side where the amalgam was thickest gave only a trace of gold, which indicated that only an exceedingly small percentage of gold had been absorbed by the copper.

In the discussion of this article J. E. Breakell advanced the idea that the non-absorption of amalgam by the copper was due to the silver plating of the latter. If a plain, unannealed copper plate had been used, he believed that more precious metal would have gone into the copper and a smaller percentage recovered by the method described. His method of recovering absorbed gold and silver is as follows: (1) After cleaning up in the ordinary way by squeegee, scrapers, etc., the plate is taken up and well washed, after which it is heated evenly all over at a temperature just sufficient to eliminate all the mercury. (2) While still warm, coat the upper surface with a mixture of finely powdered sal ammoniac and hydrochloric acid made to the consistency of a paste, and applied, conveniently, with a 3-in. paint brush. (3) Expose the plate to a moderately high temperature, until evenly red-hot all over. (4) While red-hot, plunge suddenly into a tank of cold water, when nearly all the gold comes away in the form of scales, ranging from small particles up to pieces of 2 in. diameter. About 10 per cent. adheres to the surface of the plate, but is easily detached by chipping with a suitable edged tool. The time consumed is about an hour. The tank should be large enough to avoid bending the plate. The scales recovered are black in color, and contain possibly about 25 per cent. copper, which may be removed by repeated boiling in nitric acid. This method was used very sucessfully for the scaling of eight large battery plates from a 20-stamp mill in the vicinity of Boksburg, Transvaal. The time consumed was 24 hours and most of this time was taken up in straightening the plates out shown in the table on page 376.

Intervals of Time Between Dressings.[1]—At the Simmer and Jack mill it appeared that longer intervals might occur between the dressing of plates. This would save considerable labor, because, under the new regulations, covers with double locks have to be used on all of the mill plates, and two white men have to be present whenever the covers are removed. Trials from November, 1908, to April, 1909, gave the results shown in the table on page 376.

This table shows that the 12-hour dressing interval yields a little higher extraction, probably due to the fact that the material passing over the plate was a little finer. It certainly indicates that there is no loss by

[1] G. O. Smart. *Journ.* Chem., Met. and Min. Soc. of South Africa, IX, 425; X, 141, 177. Abstracted in *Min. and Sci. Press*, XCIX, 503; *Eng. and Min. Journ.*, LXXXVIII 556.

EXTRACTION ON MILL PLATES.

	Heads. Dwt.	Tails. Dwt.	Extraction. Dwt.	Extraction. Per Cent.	Size of Pulp.		
					Above 0.01. Inches. %	0.01 to 0.006. Inches. %	Below 0.006 Inches. %
Nov., 1908, to Jan., 1909, 8 hours between dressings..................	7.584	3.952	3.632	47.890	40.90	13.03	46.07
Feb. to April, 1909, 12 hours between dressings........................	7.359	3.818	3.541	48.118	38.27	12.97	48.77

the less frequent dressing. Further experiments, from February 11 to April 19, 1909, gave the following averages: The plates were dressed each day at 6 a.m. and were not dressed again during the period of sample taking. The average extraction three hours after dressing was 50.48 per cent. of the gold; six hours after dressing, 53.57 per cent.; nine hours after dressing, 50.39 per cent. and 12 hours after dressing, 49.10 per cent. The extraction thus increased during the first six hours after dressing and dropped off for the remaining six hours of the period. The variations are not great, however, and as a result, the 12-hour interval of dressing was adopted in this mill. To obtain good results with this interval, the plates must be kept in good order and a sufficient coating of amalgam left on them after clean-up. If they are scraped down to bare copper, good amalgamation will not be obtained, even though they are dressed every hour.

The discussion of this paper showed that at the Village Main Reef mill they had extended their interval of dressing to eight hours but had not felt that they could go to twelve hours. The Simmer Deep and Jupiter mills have gone to the twelve-hour interval. The joint mill of the Knight's Deep and Simmer & Jack East made some tests and found in one case a recovery of 56.9 per cent. four hours after dressing, and 57.3 per cent. eight hours after dressing. In another test the recoveries at intervals of 4, 8, 10 and 12 hours after dressing were respectively, 44.2, 45.5, 44.8 and 43.7 per cent. After the 12-hour sample was taken the plates were immediately dressed and another sample was taken, showing an extraction of 46.1 per cent., whence they concluded that they could easily increase their intervals to eight hours, but that twelve hours was a little too long. Previously, their interval had been four hours. The May Consolidated mine has increased its interval between dressings from four hours to eight hours without lessening the extraction.

All of the foregoing figures apply to the first plates. Some tests at the Simmer & Jack mill on the plates following the tube-mills, extending over an interval of twelve days, gave results shown in the table:

EXTRACTION ON PLATES AFTER TUBE-MILLING.

Hours After Dressing.	Per Cent. Extraction.	Sizing Test.		
		Size. Inches.	Entering Tubes.	Leaving Tubes.
15 min.	26.05			
2 hours	29.27			
4 "	27.04	Above 0.01	59.97	16.80
6 "	25.01	0.01 to 0.006	23.25	24.88
8 "	23.87	Below 0.006	16.78	58.32
10 "	18.44			
12 "	19.17			

As a result, an interval of twelve hours was adopted for the tube-mill plates, for some time, without any apparent falling off in the extraction.

Location of Amalgamated Plates.[1]—The ordinary location of the amalgamated copper plates in a stamp mill, directly in front of the stamps, is accompanied by a number of disadvantages. Among the advantages connected with a separate plate room are the following: (1) The absence of vibration caused by the stamps. (2) Much better lighting during daylight hours can be provided. (3) Increased space for working about the stamps, making repairs, etc. (4) Increased space also about the tables, which can be placed as far apart as desired, and built at a convenient hight above the floor of the plate room. (5) Better arrangements for altering the grade of the tables, etc. (6) Ease with which a system of pulp distribution can be arranged so that the supply of pulp can be shut off from any one table, and be distributed equally between the others, or as many of them as may be wished. This obviates the necessity of having to hang up stamps when dressing the plates or collecting amalgam. The ordinary plan of avoiding this by diverting all the pulp on one plate to a single adjoining plate is obviously bad practice. (7) In consequence, there is no need for the amalgamator to hurry over his work. He can take his time, and do his work thoroughly. (8) By having the doors and windows of the plate room properly secured, casual pilfering by dishonest employees can be prevented, and the risk of robbery by outsiders reduced. (9) It becomes a simple matter to classify the pulp, if desired, before passing it over the plates, and to vary the mode of treatment for each class.

The author does not think that there is anything to be said against isolating the plate room, except the slight initial cost, the need, in some cases, of an elevator to give the fall required for the launder conveying the pulp to the plate room, and the fact that in small mills, in which only one attendant is employed to look after the stamps and plates, the latter would be less constantly under his eye.

[1] *Mex. Min. Journ.*, Sept. 15, 1908. Abstracted in *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 186.

Electrochemical Amalgamation.[1]—Considerable work has been done in investigating the action of electricity in connection with amalgamation and with cyaniding. As far back as 1892 G. W. Warnford Lock described a successful electrochemical amalgamator before the Institution of Mining and Metallurgy. At present, this process may be applied to plate amalgamation by having a sluice covered with regular copper plate, which acts as a cathode. The current is brought by anodes, each dipped into the water flowing over the surface of the plate. The solution of bichloride of mercury fed with the water at the head of the plate serves as an electrolyte from which mercury is deposited on the cathode by electrolysis. Similarly, by adding salt to the water, sodium may be deposited. Both nascent sodium and nascent mercury act as powerful amalgamators, and rusty gold, platinum, or its alloys, are readily amalgamated. The amalgam which forms on the plate is very tenacious and bright. The electric tension is only 5 to 10 volts.

The following is the order in which amalgamating substances are arranged in order of their affinity for gold: (1) Ordinary commercial mercury; (2) chemically pure mercury; (3) sodium amalgam; (4) nascent mercury; (5) electrolytic sodium amalgam; (6) hydrogen amalgam; (7) hydrogen sodium amalgam.

Electricity can be applied to cyanide work by the use of a shallow tank with a circular copper plate on its bottom. The pulp and solution are agitated in this tank by revolving arms which act as anodes, the copper plate serving as cathode. Current is supplied at 10 or 15 volts. It is claimed that under electrolytic conditions the cyanide will attack gold which it will not ordinarily affect. As soon as this gold is dissolved it is deposited on the cathode, and cyanide is liberated in a nascent condition ready to take up more gold.

Tube-Mill Design.

New Tube-Mill Linings.[2]—Two new types of linings were patented by Messrs. Gibson and Schillie. In the one an arrangement of steel plates, curved at the outer edge, is bolted to angle-iron standards set inside the shell of the tube mill. The lining consists of fragments of any hard rock such as gold-bearing "banket" set in concrete between the plates. In the other form short pieces of worn-out drill steel are set in cement, and the spaces between them become filled with pebbles.

Tube-Mill Liners.[3]—The Brown lining is a form of ribbed lining in which for a mill of 4 ft. diameter there are eight longitudinal ribs

[1] E. E. Carey. *Electrochem. and Met. Ind.*, VII, 228. *Can. Min. Journ.*, XXX, 649; *Eng. Mag.*, XXXVII, 839; XXXVIII, 335; *Min. Journ.*, LXXXV, 617, 727; *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 26, 148; *Min. Sci.*. LIX, 311; LX, 30; *Min. Wld.*, XXX, 575, 725, 1067.
[2] *Eng. and Min. Journ.*, LXXXVIII, 1283.
[3] F. C. Brown. *New Zealand Mines Rec.*, XII, 396; *Min. Journ.*, LXXXV, 795; Abstracted in *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 151.

3x2½ in. bolted to the inside of the shell and placed 18 in. apart. For a 5-ft. mill, there are ten ribs 3½x3 in. This form of lining gives greater area inside the tube mill than a silex lining. It prevents slip of pebbles, it is easily put in and is economical in wear. In 18 months one set of liners ground 27,835 tons of hard, coarse sand and during that time only 40 per cent. of the weight of the metal was worn away.

At the Komata mine, two mills each 16x4 ft. are handling 100 tons per day. The character of the work is shown by the following table:

	On 6-Mesh.	10	20	40	60	90	120	200	Passed. 200
Before grinding	6%	14.5%	18%	13%	10.5%	13%	4.5%	6.5%	16%
After grinding					1.5%	16%	15%	8.5%	59%

The consumption of pebbles per ton of sand is 2 ℔., costing 1.72c. Wear on liners costs 1.4c.

Comparison of ribbed liners with silex liners was made at the Waihi Grand Junction mine. Total cost of wearing parts for the silex liners was 3.48c. per ton of sand ground, while for the ribbed liners it was 1.68c. and at the same time the ore was ground finer by the latter.

Ennis Tube-Mill Lining.[1]—This tube-mill liner has been introduced at Guanajuato, Mexico. It consists of removable longitudinal bars secured by bolts to the inner lining of the tube-mill shell. In the depression between the bars the pieces of quartz and pebbles are caught and take considerable of the wear. The bars have between them and the shell a fixed lining which is subject to only slight wear in the spaces between neighboring bars. The advantage of this form of lining is the reduction of weight and metal. In the tube mill, 16x4 ft., the old lining weighed 8 tons; the new lining weighs 8 tons for bars and plates, but subsequently the replacing of the bars will mean a requirement of only 3½ tons. The bars last about eight months, or about the same time as the complete set of the old-time lining.

Examples of Stamp Milling Practice.

Milling of Grass Valley, California.[2]—The principal milling plants are the North Star-Central 80-stamp mill, the Empire 40-stamp mill and the 20-stamp plants of the Idaho-Maryland, Pennsylvania and Sultana. The ore is regular free-milling quartz with 2 to 8 per cent. sulphides.

The North Star and the Central mills each have 40 stamps. The ore passes over grizzlies which yield oversize to two Blake breakers crushing to 2 in. The crushed rock is fed automatically from the ore bins to the 1000-℔. stamps which drop 96 times per min. in the order 1-3-2-5-4.

---

[1] *Min. Wld.*, XXXI, 35.
[2] A. H. Martin. *Min. Wld.*, XXXI, 1107. *Min. Sci.*, LX, 6.

Each stamp crushes 3.25 tons in 24 hours through a needle-punched screen equivalent to 25 mesh. An amalgamated plate, 4x18 ft., is placed in front of each battery of five stamps, and the pulp from each plate flows to a Dodd circular concentrating table of 10 ft. diameter. The tailings from these tables are cyanided, using percolation for the sands and agitation and Oliver vacuum filter for the slimes. The table concentrates are ground in a tube mill, run over amalgamated plates and finally cyanided, using agitation and Oliver filter. An extraction of about 93 per cent. is obtained. Crushing and concentrating cost $0.40 per ton and cyaniding costs $0.40 per ton more.

At the Empire mill, which is representative of the other mills in the district, the ore is treated by gyratory breakers, 1000-lb stamps with inside plates, outside amalgamated plates, and Frue vanners. The 40 stamps crush 90 tons in 24 hours and there are 16 vanners. Vanner tailings are treated by the Gates process. They go first to (1).

1. Settling box. Spigot to (6); overflow to (2).
2. 26 canvas tables, 12 ft. wide, 8 ft. long. Hosed off every 30 min. Concentrates to (3); tailings to (6).
3. Gates end-shake vanner, 6 x 10 ft. Concentrates to smeltery; tailings to (4).
4. Gates vanner like (3). Concentrates to smeltery; tailings to (5).
5. Two canvas tables, 15 ft. square. Hosed off every hour. Concentrates to smeltery; tailings to (6).
6. Canvas table, 22 x 60 ft. Concentrates to smeltery; tailings to waste.

Simmer Deep and Jupiter Mill.[1]—This reduction works was put into operation on Sept. 1, 1908, to treat the ore of these two companies, both under the control of the Consolidated Goldfields of South Africa, Ltd.

Separate mill bins of 5460 tons and 2525 tons capacity are provided, the ore from each mine being treated separately until it leaves the mill tables, when it mixes on entering the tube mills and thence the cyanide plant. The recovery obtained by tube milling and cyaniding is apportioned to each company on the basis of the tonnage and value of the tailings leaving each company's mill tables.

Briefly, the processes are as follows: Breaking the ore to 1¾ in. at each of the company's sorting and crushing stations; transport by hopper-bottomed cars of 35 and 45 tons capacity, drawn by a 48-ton locomotive on a 42-in. gage track; stamp milling with heavy gravitation stamps, of the Californian type, and amalgamation over stationary copper plates; tube milling and amalgamation over copper shaking tables; classification of slimes and sands by cone classifiers; treatment of sands by rotary filter tables, and wet filling of tanks with cyanide solution, with subsequent transfer and percolation with cyanide solution; treatment of slimes by the decantation process; precipitation of gold from solutions by zinc shavings, and zinc-lead couple; acid treatment of gold slimes, calcining, smelting, etc.

[1] *Journ.* Chem. Met. and Min. Soc. of South Africa, IX, 402; *Can. Min. Journ.*, XXX, 594; *Min. and Sci. Press*, XCIX 396.

The mill contains 300 stamps, arranged five in each mortar box, in blocks of 10, each 10 stamps being driven by a 50-h.p., three-phase, electric motor. The current is generated by the Victoria Falls (Transvaal) Power Company in their station at Brakpan, 20 miles distant.

The framing of the mill buildings and bins is entirely of steel girders, the bins themselves being of timber 6 in. thick on the sides and ends. The mortar boxes are of the straight-backed type, and are specially heavy, having a bottom 15 in. thick. Each box weighs 11,872 lb. These are placed on concrete foundations, a separate foundation for each 10 stamps, 17x10 ft. at the base, 15x4½ ft. at the top and 10 ft. high. Each block contains about 102 tons of concrete, and has a sheet of best rubber, ¼ in. thick, between the bottom of the mortar box and the concrete. The six holding-down bolts, 1¾ in. diameter and 7¾ ft. long, are so placed as to be readily accessible for tightening and replacing. The mortar boxes are 6 ft. high, taking a 59-in. screen frame. The hight of the screen opening is 24 in. Each box has five 1-in. openings for the admission of water from the back-water service. These are arranged so as to give a jet of water playing on each die at an angle of 45 deg. to the surface of the die. Manganese steel liners are fitted in each box to take the wear due to attrition. The stamps weigh 1670 lb. each, when new, made up as follows: Stem, 723 lb.; tappet, with gibs and keys, 252 lb.; head, 410 lb.; shoe, 285 lb. The stems are 4 in. diameter, and are placed at 10¾ in. centers. The order of the drop is 1, 3, 5, 2, 4. The set hight is 8½ in. Hight of discharge, 4 in., and number of drops 100 per min. The duty per stamp is over 8.7 tons per 24 hours, using a 500-mesh screen, with a 0.033-in. aperture. The king posts are of timber of the "built-up" type, to prevent twisting, and sit in cast-iron shoes resting on the rubber on the concrete foundations. This also obviates having an unnecessary amount of timber above the cam shaft bearings. The cam shafts are 16 ft. 3 in. long and 7 in. diameter and the majority of them are of the "Riffled Blanton" type. Other methods of fastening the cams on the shafts are also being used.

The feeder chutes are provided with sliding doors on the bins, while the feeders themselves are driven by ¾-in. manila ropes from rocker bars placed at the back of the king posts above the cam platforms. The front of the cam platform is supported directly from the concrete foundations, independently of the king posts. The reduction of the vibration on the platform, due to this construction, is very noticeable.

The mill clean-up room is spacious, and contains three revolving drums for cleaning amalgam, three amalgam barrels, three bateas, and a clean-up table, sump, etc. Besides these, a small tube mill, 6 ft. 6 in.x5 ft., with a shaking table; two 10x10-ft. conical-bottom vats, and a zinc precipitation box, for the treatment of black sands, barrel tailings, etc., by tube-milling and cyaniding, are provided. Two retorts and three Cornish fires are also placed in this room, so that the amalgam is retorted and the bullion run into bars before leaving the mill buildings.

The arrangement of the batteries back to back, 150 stamps on each side with the bins between, admits extensions to be made easily at the southern end of the mill. The motors drive down to small counter-shafts, one for each 10 stamps (placed below the feeder and motor floor), by 11-in. belts. Thence the drive goes direct by a 21-in. belt to the 7-ft. cam-shaft pulleys. The counter-shafts are moved by means of bevel-geared wheels, so as to take up the stretch in the motor and cam-shaft pulley belts.

On leaving the mill tables, the tailings pass through mercury traps and launders to the tailings pits, of which there are two, one for the 200 Simmer Deep and one for the 100 Jupiter stamps. From these the pulp is elevated by 8-in. centrifugal pumps, three in one pit and two in the other (only one in each pit being normally run at a time), to the cone-shaped tube-mill classifiers. Of these there are two for each of the four tube mills, 45 in. diameter at the overflow, and 7 ft. deep, with a $\frac{7}{8}$-in. nozzle at the underflow. These in turn deliver into a dewatering cone, 36 in. diameter and 5 ft. deep for each tube mill, with a $1\frac{1}{4}$-in. nozzle at the underflow. The overflow from these dewatering cones joins the stream at the tube-mill outlets so as to make the reground pulp sufficiently fluid to pass over the shaking tables, of which there are five, 12 ft. by 4 ft. 7 in., for each tube mill, running at 200 shakes per minute. The tube mills are of the Krupp type, are 22 ft. by 5 ft. 6 in. inside the shell, and are lined with $5\frac{1}{2}$-in. local flint sets. Each mill is driven by a separate 125-h.p., three-phase, electric motor and, running at 30 r.p.m., takes about 104 h.p. The pulp passes from the underflow of the dewatering cones through Pryce's feeders, through which are also fed the pebbles to maintain the pebble load in each mill at about 6 in. above the center of the mill. These pebbles are pieces of ore, about 4-in. size, picked off the belts of the sorting stations and delivered to a special bin from which they are trammed to the tube mills in small cars of 10 cu.ft. capacity. The average working load of pebbles in each mill is about 10 tons, and about five tons per mill per day are consumed.

The tailings from the shaking tables join the main pulp in the tailings pits and are re-elevated to the classifiers; any particles that still require regrinding pass down again through the classifiers, while the remainder overflows with the fine product in the mill tailings to the cyanide works.

Bibliography of Gold Milling in 1909.

For lack of space, the following articles are referred to by title only: The reader is also referred to the Bibliography for Progress in Ore Dressing in this volume.

Anonymous. "Stamp Duty on the Rand." (*Eng. and Min. Journ.*, LXXXVII, 817).

Anonymous. "Order of Drop of Stamps." (*Eng. and Min. Journ.*, LXXXVIII, 1034.)

Anonymous. "Arrangement of Splash Plates and Traps at the Laurentian Mill." (*Eng. and Min. Journ.*, LXXXVIII, 1280.)

Barbour, P. E. "Foundations of Goldfield Consolidated Mill." (*Eng. and Min. Journ.*, LXXXVII, 1173.)

Crawford, A. J. F. "Keyless Tappet." (*Mines and Minerals*, XXIX, 258.)

Del Mar, A. "Evolution of the Gravity Stamp Mill." (*Eng. and Min. Journ.*, LXXXVII, 890. Abstr. in *Journ.* Chem. Met. and Min. Soc. of South Africa, X, 117.)

Del Mar, A. "Concrete Battery Posts." (*Eng. and Min. Journ.*, LXXXVIII, 598.)

Hermann. "The Mechanics of Stamps." (*Oest. Zeit. f. B. u. H.*, LVII, 275, 297.)

Hofman, H. O. and Hayward, C. R. "Experiments in Pan Amalgamation." (*Bull.* A. I. M. E., June, 1909, 513. Abstr. in *Min. and Sci. Press*, XCIX, 529.)

Jory, J. H. "Electrolytic Amalgamation." (*Min. Wld.*, XXX, 885; XXXI, 687.)

Mac Farren, H. W. "Hints on Amalgamation." (*Min. Wld.*, XXX, 891.)

McGraw, D. F. "Alling Process of Electrochemical Amalgamation." (*Min. and Sci. Press*, XCVIII, 897.)

GRAPHITE.

By Frederick W. Horton.

The United States consumes approximately one-third of the world's output of graphite. As domestic production is insufficient to supply this demand, considerable quantities are imported. Ceylon is the chief source of the foreign supply, but imports are also derived from Austria, Bavaria and Mexico. The accompanying table shows the production, imports and consumption of graphite in the United States for a period of years.

STATISTICS OF GRAPHITE IN THE UNITED STATES.

Year.	Refined Crystalline Graphite.						Amorphous Graphite. Production.		Artificial Graphite. Production.	
	Production.		Imports.		Consumption (a).					
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Tons 2000 lb.	Value.	Pounds.	Value.
1897	993,138	$ 44,691	19,113,920	$ 270,952	20,107,058	$ 315,643	1,200	$11,400	162,382	$10,149
1898	1,647,679	82,385	30,199,680	743,820	31,847,359	826,205	1,200	11,400	185,647	11,603
1899	3,632,608	145,304	41,586,000	1,990,649	45,218,608	2,135,953	1,030	8,240	405,870	32,475
1900	4,103,052	164,122	32,298,560	1,389,117	36,401,612	1,553,239	1,045	8,640	860,750	68,860
1901	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800	2,500,000	119,000
1902	4,176,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964	2,358,828	110,700
1903	4,525,700	164,247	32,012,000	1,207,700	36,537,700	1,371,947	16,591	71,384	2,620,000	178,670
1904	4,357,927	162,332	25,350,000	905,581	29,707,927	1,067,913	19,115	102,925	3,248,000	217,790
1905	4,260,656	170,426	34.914,611	983,034	39,175,267	1,153,460	(b)21,953	80.639	4,595,500	313,979
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	(b)16,853	(c)	4,868,000	312,764
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	(b)26,962	138,381	6,924,000	483,717
1908	3,433.039	149,763	22,912,714	762,267	26,345.753	876,030	1,821	8,230	7,385.511	502.667
1[illegible]	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	1,703	14,528	6,870,529	467,196

(a) Neglecting the small re-export of foreign product. (b) Statistics of the U. S. Geological Survey. Largely graphitic shale.; not included in our statistics of 1908-09. (c) Not reported.

Prices.—It is difficult to quote specific prices for the numerous grades of graphite on account of the wide variation in the quality of the material. Domestic crystalline graphite brought from 3 to 8c. per ℔., according to grade, the average price obtained for the entire output being 6c. per ℔. The New York production, derived largely from the mines of the Dixon Crucible Company, is of sufficiently high grade for the manufacture of crucibles and brings the best prices. The output of Pennsylvania and Alabama was marketed at from 3 to 8c. per ℔. New York quotations on Ceylon graphite were as follows: Flying dust, 2@4c.; dust, $2\frac{1}{4}$@5c.; chip, 4@8c.; lump, $5\frac{1}{2}$@12c.; large lump, $8\frac{1}{4}$@$10\frac{1}{2}$c. The wide limits of these quotations cover grades from the poorest to the best. The classification of the graphite depends largely on the carbon content, but also on the relative amount of iron and silica contained and the texture, color and brightness of the material. Fancy grades contain at least 95 per cent. carbon; high grades, over 90 per cent.; good grades, 85 to 90 per cent.; medium grades 80 to 85; and poor grades, 70 to 80 per cent. The prices obtained for domestic amorphous graphite ranged from $3 to $20 per ton, according to the purity of the material. The average price received was about $8.50 per ton.

Graphite in the United States.

Alabama.—In 1909 the principal producers of graphite in Alabama were the Allen Graphite Company and the Ashland Graphite Company, both operating deposits of crystalline graphite in Clay county. The Ashland company is the successor to the Entiachopes Graphite Company and has taken over the mine of the latter company near Ashland. The property of the Allen company is at Quenelda. The Clay county deposits consist of an enormous zone of non-micaceous and badly weathered granite, containing from 3½ to 6 per cent. of crystalline graphite of good quality. The graphite is distributed quite uniformly throughout the rock and seems to occupy the place of mica, which is a regular constituent of the granite at other localities in the county. The graphitized zone extends from Quenelda to Ashland, a distance of over nine miles and has a width of several hundred feet and a great depth. The rock can be mined cheaply and is of such character that it can be milled without injury to the graphite flakes. With further development this deposit alone should place Alabama in the front rank as a producer of flake graphite. In Chilton county deposits of crystalline graphite occur in a zone of micaceous schist which has been traced for over four miles and has a width of several hundred feet. Two mills have been erected on this deposit within the last seven years and considerable graphite has been mined. The production of the State in 1909 amounted to 1,618,983 lb. of crystalline graphite, valued at $56,101.

Colorado.—The Federal Graphite Company, with a mine three miles east of Turret in Chaffee county, made a small output of amorphous graphite. The product was shipped to Warren, Ohio, for refining.

Georgia.—Although this State contains deposits of crystalline graphite, none of them are of commercial importance. In the vicinity of Cartersville and Emerson in Bartow county, considerable quantities of graphitic schist were mined. This material contained from 6 to 10 per cent. of amorphous granite and was used as a filler for improving the color and weight of certain commercial fertilizers and for making brick.

Idaho.—During 1909 a graphite mine was opened by Hampton & Griffith near Ketchum. The material is of the amorphous variety and contains from 20 to 40 per cent. of graphitic carbon. Over 1000 tons were mined but no shipments were made.

Michigan.—The Detroit Graphite Company, of Detroit, operated deposits of graphite schist and slate in Baraga county. The product, which is known as Baraga graphite, was sold to paint manufacturers. The large graphite factory, of the United States Graphite Company, at East Saginaw, derived its entire supply of raw material from the deposits of amorphous graphite owned by the company in Sonora, Mex. These deposits are described elsewhere in this article.

Montana.—The Crystal Graphite Company, at Dillon, in Beaverhead county, shipped a small tonnage of crystalline graphite.

New Jersey.—The graphite deposits of New Jersey have been mined spasmodically for years, but most of them have been found lacking in either the quality or quantity of the contained graphite and work on them has been abandoned. At the present time the Asbury Graphite Mills in Warren county is the only producer. The deposit mined consists of beds of partly decomposed gneiss containing an average of about 3 per cent. crystalline graphite. The Raritan Graphite Company at High Bridge in Hunterdon county has discontinued operations.

New York. (By D. H. Newland.)—The usual quota of crystalline graphite was supplied by the Adirondack mines in 1909, the production amounting to 2,826,000 lb. For several years the output has averaged about 2,500,000 lb. with the high mark of 3,900,000 lb. in 1905 and the low mark of 1,932,000 lb. in 1908. The industry has shown little tendency toward expansion, notwithstanding the fact that a large amount of capital has been expended in opening new mines and erecting mills. The American mine of the Joseph Dixon Crucible Company still remains without a rival in production or as a successful financial enterprise. Descriptions of this property, which is in a way illustrative of the general character of the Adirondack deposits, have been published in previous volumes of THE MINERAL INDUSTRY.

A development of more than ordinary promise was under way during 1909 in the vicinity of the American mine. The series of limestones and schists were found by surface exploration and drilling to extend to the southwest for a mile or more, and to contain large beds of graphitic rock very similar to that mined by the Dixon company. There are two principal beds in the series, of which the upper measures from 6 to 14 ft. in thickness and the lower one from 4 to 5 ft. The supply of rock is undoubtedly very extensive, but it is a little leaner and the graphite of somewhat smaller flake than the average of the American mine. It is planned to make mill tests during the current season and, if the outcome should be favorable, a successful enterprise is in prospect. The property is owned by W. H. Faxon, of Chester.

Pennsylvania.—In 1909 the production of crystalline graphite in Pennsylvania amounted to 1,202,416 lb., valued at $58,006. The chief producers were the Pennsylvania Graphite Company, of Uwchland, the Chester Graphite Company, and the Sterling Graphite Company, the last two of Chester Springs. The Pennsylvania deposits are of moderate size and consist of mica schist containing about 3 per cent. of graphite. The milled product is of high grade and brings from 2 to 9c. per lb. The United States Graphite Company, of Chester Springs, and the Continental Graphite Company, of Ryers, discontinued operations. The property of the latter was taken over by the Acme Graphite Company, but the new owners made no production during the year. The Federal Graphite Company, which has been idle since 1906, was reorganized, and expects to begin production in 1910, under the name of the Federal Carbon Company.

Rhode Island.—About 500 tons of highly graphitic shale was mined in Rhode Island in 1909. This material was worth about $6 per ton and was ground and used for foundry facing. The largest workings in the State are at Cranston, a suburb of Providence.

Utah.—During 1909 the Humber Mining Company, of Salt Lake City, opened a graphite deposit in Box Elder county, and shipped a small tonnage of amorphous graphite which it used for experimental purposes. The mine is situated about two miles east of Perry, a station on the Oregon Short Line railroad. The deposit, in the form of a well-defined vein about 20 ft. thick, was crosscut by prospectors in 1864, but remained undeveloped until recently. The company has let contracts for the erection of a plant at Ogden, where it will use the graphite in the manufacture of mineral paint.

Wisconsin.—The Wisconsin Graphite Company, of Stevens Point, mined a considerable tonnage of graphitic schist. The entire output was used in the manufacture of paint.

Artificial Graphite.—As may be seen from the preceding table, there was a slight decrease in the amount of artificial graphite produced by the International Acheson Graphite Company, at Niagara Falls, in 1909. Under ordinary conditions there would have been an increase, but the company devoted several months of the year to enlarging its plant, and thus did not make the output which the trade demanded. The new process of graphitizing metals has already created a considerable demand for artificial graphite. This graphitizing process results in the union of graphite with the surface of a metal, thus rendering it rust and acid proof. To the canning and packing industries the new process is of great interest, as it makes possible almost perfect sanitation in the handling of food products.

Graphite Mining in Foreign Countries.

Africa.—The Transvaal Mining and Milling Company, Ltd., operated a mine in the Zoutpansberg district, Transvaal, and started a small mill in Johannesburg to prepare the graphite for the local market. In Natal deposits carrying from 7 to 10 per cent. of crystalline graphite of excellent grade were discovered on the Umzimkulu river near Port Shepstone.

Australia.—The Australian Plumbago Company opened up extensive deposits of amorphous graphite on the Donnelly river near Bridgetown, W. A. The material proved of very low grade and after mining about 300 tons operations were suspended.

Austria.—In 1909 exports of graphite from Austria amounted to 18,484 metric tons. Imports were 660 metric tons.

Bavaria.—The production of graphite in Bavaria in 1909 amounted to 6774 metric tons, valued at $9.34 per ton. The output was derived from 58 mines and 814 persons were employed in the industry. The production in 1908 was 4844 metric tons.

Canada.—The production of graphite in Canada in 1909 was 730 tons, valued at $37,624, as compared with an output of 251 tons, valued at $5565 in 1908. A new discovery of graphite was made at St. Jovite, which is 60 miles northwest of Montreal, on the Montreal & Nomining branch of the Canadian Pacific Railway. Some flake graphite from this deposit was marketed in the United States.

Ceylon.—This country furnishes about one-quarter of the world's supply of graphite. In 1909 exports amounted to 26,866 metric tons as compared with 22,198 metric tons in 1908. Approximately, one-half of this amount went to the United States and one-fourth to the United Kingdom. The graphite has a fibrous structure which makes it particularly suitable for the manufacture of crucibles, and the Ceylon product therefore commands the highest prices.

Korea.—In 1908 the production of graphite in Korea amounted to 7520 metric tons, as compared with 828 metric tons in 1907. The principal mines are situated in the southeastern and northwestern portions of the peninsula and the business is almost entirely in the hands of Japanese. In the southeastern section the two largest mines belong to the Komiya Graphite Company, a Japanese firm of Iriyemachi Fusan. One of these mines is in the Cheng-san district near Whang-gan station on the Seoul-Fusan railway and is therefore favorably situated as regards transportation facilities. The other mine is in the district of Sang-jin and the graphite is transported by river boats to another station on the Seoul-Fusan line. In an investigation of the graphite deposits of Korea by the Government, the Cheng-san deposit was estimated to contain 2,000,000 long tons and that of Sang-jin, 1,600,000 tons. The cost of production at these mines is estimated at $11.46 per long ton. The price received for the mineral at present is $12.29 per ton. The graphite is of the amorphous variety and of rather low grade, the proportion of carbon being as low as 60 per cent. The amorphous graphite from northern Korea is of better quality than that from the southern mines and contains as high as 85 per cent. carbon. Several occurrences of crystalline graphite have been reported but the extent of the deposits has yet to be ascertained. The entire production of the country is at present of the amorphous variety. The material is low grade and only suitable for use in foundry facings, paint, stove polish, etc. Exportation is principally to Germany, England and the United States, but there are prospects of a good demand from manufacturing houses in Tokio and Osaka, and from the Government arsenals in Japan.

Mexico.—The Santa Maria mines in central Sonora are the largest and most important mines of amorphous graphite in the western hemisphere. They are situated about 20 miles south of La Colorado and are owned by the United States Graphite Company of Saginaw, Mich. The deposits consist of at least seven beds of graphite intercalated with metamorphosed sandstone and standing at high angles. The bed now being mined ranges in thickness from 9 to 10 ft. The graphite was undoubtedly formed from coal beds by the metamorphic action of an intrusive granite which in places forms the wall rock of the deposit, and in other instances is present as dykes, which pierce the beds. The graphite is wholly amorphous and is extremely soft and pliable. An analysis of a run-of-mine sample shows graphitic carbon, 86.75 per cent.; silica, 7.6; ferric oxide, 0.65; alumina, 5; but specimens may be picked which carry 95 per cent. graphitic carbon. The material is hauled from the mine to La Colorado by mule teams and shipped to Saginaw, Mich., where it is ground and concentrated by air flotation and bolting. A large part of the best pencils both of European and American manufacture are made from this graphite. The pencil trade, however, takes but a small quantity of the best material. A great deal larger quantity of good graphite is used in the manufacture of lubricants, while the poorer material is employed for foundry facings, paint and stove polish. Graphite is found in many other places in Sonora, notably a few miles north of Torres, where a Pennsylvania company owns a deposit from which some graphite has been shipped. However, this property is now idle, due, it is said, to the low grade of the material. Graphite of good quality is also found in the State of Oaxaca, but the deposits are small.

Siberia.—A deposit estimated to contain over 500,000 tons of high-grade crystalline graphite has recently been discovered on the Kureike river, a tributary of the Yenissei in northern Siberia. The graphite contains 92 per cent. carbon and in point of quality ranks second only to the Ceylon product. It can be delivered in St. Petersburg at one-fifth the cost of Ceylon graphite, and as it is only slightly inferior to the latter for the manufacture of crucibles, it will doubtless supply a large portion of the Russian demand.

WORLD'S PRODUCTION OF GRAPHITE.
(In metric tons.)

Year.	Austria.	Bavaria.	Canada.	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	Totals.
1897......	38,504	3,861	395	19,275	61	6,650	391	759	99	450	69,350
1898......	33,062	4,593	1,107	78,509	61	6,435	347	1,365	50	824	126,353
1899......	31,819	5,196	1,188	29'037	1,548	9,990	53	2,305	35	1,648	80,960
1900......	33,663	9,248	1,743	19,168	1,859	9,720	94	2,561	84	1,799	79,939
1901......	29,992	4,435	2.004	22,707	2,530	10,313	88	762	56	1,800	74,688
1902......	29,527	5,023	993	25,593	4,648	9,210	97	1,434	63	1,895	78,371
1903......	29,590	3,719	660	24,492	3,448	7,920	114	1,404	25	2,053	73,435
1904......	28,620	3,784	410	26,478	2.955	9,765	216	970	55	2,045	75,298
1905......	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	87,047
1906......	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	93,909
1907......	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	105,889
1908......	44,425	4,844	227	22,198	2,919	12,914	177	1,076	66	1,557	(d)97,923

(a) The figures for 1897, 1899, 1907 and 1908 are exports; the enormous production in 1898 as reported in officia government publications is not reflected in the exports of that year which amounted to 24,349 metric tons. (b) Exports (c) Crystalline graphite. (d) Includes the production of 7,520 metric tons in Korea.

Bibliography.

The following papers on graphite appeared in the technical press in 1909:

Anonymous. "The Mining of Graphite in Ceylon." (*Foundry*, July, 1909; 3 pp.)

Chester, F. D. "The Flake Graphite Industry in the United States." (*Eng. and Min. Journ.*, Oct. 16, 1909; ⅔ p.)

Chester, F. D. "Concentration of Flake Graphite." (*Eng. and Min. Journ.*, Oct. 23, 1909; 1 p.)

Hess, F. L. "Graphite Mining Near La Colorado, Sonora, Mexico." (*Eng. Mag.*, Oct., 1909; 13 pp.)

Ihne, F. W. "Graphite in the South." (*Mfrs.' Rec.*, Jan. 7, 1909; 4 pp.)

Ihne, F. W. "Graphite in the United States." (*Min. Sci.*, Sept. 30, Oct. 7 and 14, 1909; 8 pp.)

GYPSUM.

The general betterment in business conditions in 1909 was reflected by a considerable improvement in the gypsum industry. The domestic output surpassed that of any previous year and there was a substantial increase in the quantity of gypsum imported. The principal producing States were New York, Michigan, Iowa, Ohio, Kansas, Virginia, Texas and Colorado. In all 18 States reported a production. The United States Gypsum Company was the largest producer in the country, operating at least 35 plants situated in nine different States. The statistics of the industry for a period of years are given in the accompanying tables:

STATISTICS OF GYPSUM IN THE UNITED STATES.
(In tons of 2240 lb.)

Year.	Production.		Imports.					
			Crude.		Ground or Calcined.		Plaster of Paris.	Total Value of Imports.
	Quantity. (b)	Value. (c)	Quantity.	Value.	Quantity.	Value.	Value.	
1896	195,553	$583,136	180,269	$193,544	3,292	$21,982	$11,722	$227,248
1897	268,187	889,177	163,201	178,686	2,664	17,028	16,715	212,429
1898	281,130	864,415	166,066	181,364	2,973	18,501	40,979	240,844
1899	376,840	1,155,581	196,579	220,603	3,265	19,250	58,073	297,926
1900	432,323	1,316,255	209,881	229,878	3,109	19,179	66,473	315,530
1901	588,981	1,577,493	235,204	238,440	3,106	19,627	68,603	326,670
1902	(a) 728,998	2,089,341	305,367	284,942	3,647	23,225	52,533	360,700
1903	(a) 930,093	3,792,943	265,958	301,379	3,526	22,784	54,434	378,597
1904	(a) 840,104	2,784,325	294,238	321,306	3,278	11,276	23,819	356,401
1905	(a) 931,475	(d) 821,967	356,457	402,378	3,471	20,883	22,959	446,220
1906	(a) 1,375,588	3,837,975	390,178	464,724	3,203	22,821	21,297	508,842
1907	(a) 1,564,061	4,942,264	405,278	486,205	1,767	12,825	(e) 38,920	537,050
1908	(a) 1,537,346	4,138,560	267,988	314,845	2,296	16,093	(f) 26,733	357,671
1909	(g)	(g)	315,643	376,784	3,068	21,796	(f) 26,548	425,128

(a) Statistics of the U. S. Geological Survey. (b) Represents the amount of crude gypsum quarried. (c) Represents the value of the marketed gypsum, including its various finished forms. (d) Value of crude material. (e) Includes $1,392 in gypsum manufactures. (f) All other manufactures of gypsum, including gypsum for pearl hardening for paper makers' use. (g) Statistics not yet available.

To the trade the most important event of the year was the reduction of the import duty under the Payne tariff. The existing duty is 30c. per ton on crude gypsum and $1.75 per ton on the ground or calcined product, a reduction of 20 and 50c. per ton from the rates of the old tariff. Under the Dingley schedule about one-sixth of the domestic consumption was supplied by imports from Nova Scotia and New Brunswick. The reduced duty will doubtless result in raising this

PRODUCTION OF CRUDE GYPSUM IN THE UNITED STATES.
(In tons of 2000 lb.)

States.	1906. (a)		1907. (a)		1908.		1909 (a)	
	Tons.	Value. (b)	Tons.	Value. (b)	Tons.	Value.	Tons.	Value.
Cal., Ohio and Va.	(e)202,376	$536,940	(e)283,132	$963,583	(e)272.698	$851,743	(g)	....
Colo. and Wyo.	(f)	....	(f)	....	(f)	....	(g)	....
Iowa, Kan. and Tex.	(c)639,885	1,546,188	690,315	1,969,266	370,454	846,984	(g)	....
Michigan	341,716	753,878	317,261	681,351	327,810	491,928	(g)	....
New York	288,631	749,896	324,507	800,225	318,046	760,759	378,232	906,601
Oklahoma	(d)	....	(d)	....	(h)272,193	599,862	(g)	....
Other States	67,977	251,073	136,533	527,839	160,628	587,284	(g)	....
Total	1,540,585	$3,837,975	1,751,748	$4,982,264	1,721,829	$4,138,560	(g)	....

(a) Statistics of the U. S. Geological Survey. (b) Value includes that of prepared products. (c) Includes Oklahoma. (d) Included with Iowa, Kansas and Texas. (e) Includes Nevada and Oregon. (f) Included in "Other States." (g) Statistics not yet available. (h) Includes Texas.

proportion considerably, since it enables producers in those provinces to place a superior grade of crude gypsum on the New York market at a cost of about $2.70 to $3.20 per ton.

Market Conditions and Prices.—The market for gypsum and its products was fairly active during 1909. The price of domestic crude rock ranged from $0.75@1.25 per ton, f.o.b. mine. Nominal quotations in the New York market on land plaster (fertilizer) were $5 per ton and on ground rock from $4@7 per ton. The average price of all the gypsum products of the State of New York in 1909 estimated upon the total production was $2.40 per short ton.

Gypsum Mining in the United States.

Alaska.—The Juneau district was the only producer of gypsum in Alaska. The Pacific Coast Gypsum Company was the principal operator, shipping the product of its mine at Gypsum to its mill at Tacoma, Wash., where it was used in the manufacture of plaster. During the last two or three years the industry has grown rapidly, monthly shipments increasing from about 1000 tons in 1908 to about 3000 in 1909.

Michigan.—Gypsum is found in remarkable abundance and purity at Grand Rapids and Alabaster, and in moderate quantities at various other places in Michigan. The production of the mineral and the manufacture of its products form an important and growing industry. The principal producers in the State in 1909 were the United States Gypsum Company and the Grand Rapids Plaster Company. The gypsum business is practically confined to Grand Rapids, where the mineral is mined in large quantities, and ground and prepared as a basis for wall tintings, wall decorations, stucco plasters, fertilizers and other uses. For wall tintings and decorations, alabastine and allied gypsum products are among the best things made. On account of the excellent sanitary properties of these articles and the ease with which they may be applied, they are becoming popular in the United States and in many parts of Europe. The stratum of gypsum at Grand Rapids is 18 to 20 ft. in thickness, and is found from 1 ft. to 16 or 18 ft. below the surface. It covers a considerable area and affords a large supply to draw upon.

New York. (By D. H. Newland.)—The gypsum industry in New York has undergone revolutionary changes during the last decade. Production has increased nearly tenfold in that time; the small-scale desultory operations of early years have given place to systematic mining with the use of approved methods and appliances; and whereas the output was formerly marketed as raw gypsum, largely for agricultural purposes, it is now converted mainly into wall plasters in plants run in connection with the mines. Also the center of the industry has moved to the western part of the State, though for a long time the production was supplied mostly by Madison, Onondaga and Cayuga counties in the eastern section. The development of the calcined plaster trade has furnished the impetus to this progress.

The gypsum is distributed over an area more than 150 miles long which extends from the Niagara river nearly due east into Madison county. The workable deposits range from 4 or 5 ft. to 60 ft. in thickness. They consist of regularly stratified layers of rock gypsum included within shales and limestones of the Salina formation. The heavier beds outcrop in Onondaga and Cayuga counties, where they are worked by open-cut methods. Underground mining is pursued in the western section, as the beds there are only from 4 to 7 ft. thick and do not outcrop at the surface, being covered by 40 ft. or more of limestone and glacial material. The mines are entered through adits and by vertical shafts from 50 to 70 ft. deep. They are often lighted by electricity, artificially ventilated and are drained by pumps when necessary. Gas, electricity and steam are used for power purposes. Gas is supplied from the natural-gas belt of Erie county, and one of the companies uses electricity from Niagara Falls.

The maximum gypsum content of the rock as mined is about 95 per cent., the western section yielding the highest quality. Though the gypsum is darker than that found in the States further west, it is well adapted for making wall plasters, plaster boards, etc., which do not require a perfectly white plaster. The calcined product is generally lighter in color than the crude rock as a part of the coloration is due to organic matter that is consumed or driven off in the burning process. The chief impurities are clay, lime and magnesia carbonates and silica. The gypsum content of rock shipped to grinders of agricultural plaster and to portland cement works ranges from 65 per cent. up.

There are eight companies that have calcining plants at their mines, while there are two or three additional plants in the State which use the local gypsum, in part at least, for calcined plasters. Some of the rock is also shipped to other States for manufacture. Garbutt, Oakfield and Akron are the principal centers of the calcining industry. The kettle process of calcination is favored by most companies, though the Cummer rotary kiln which represents an important advance as regards fuel economy has been installed in the plants of the Lycoming Calcining Company at Garbutt and of the Niagara Gypsum Company at Oakfield. The general practice of the plants does not differ materially from that usually followed elsewhere in this country, as described in previous volumes of THE MINERAL INDUSTRY. In fact the technology of gypsum plasters had become well matured before their manufacture was introduced in New York State.

In 1909 the output of crude rock amounted to 378,232 tons, valued at $906,601. In 1908 it was 318,046 tons, of which 95,146 tons were shipped in crude or crushed form largely to portland cement works in New York and Pennsylvania; 5712 tons were made into land plaster; and most of the remainder converted into calcined plasters of which the production was 160,930 short tons.

Ohio. (By J. A. Bownocker.)—The one known gypsum deposit of commercial importance in Ohio lies on a peninsula made by Lake Erie and Sandusky bay. The deposit is about one mile wide and two miles long and lies between the Lake Shore railroad and the bay. The rock is estimated to average about 5 ft. in thickness. Sometimes it has a covering of drift only, but more commonly of limestone and drift, the former of Upper Silurian age. The color of the gypsum varies, usually ranging from snow-white to dark gray. It is quite compact and massive. The rock was first mined many years ago, at which time it was largely used as a fertilizer. Later it found a market for ornamental purposes. About 1893 its use for plaster was begun and that is now the one great demand. Minor uses are in making portland cement, plate glass, fire proofing and as a fertilizer. The market is an extensive one, including the territory east of the Mississippi river. Four plants exist, but only two of these are now operating. These are the works of the American Gypsum Company and the United States Gypsum Company. The preparation of the rock consists in quarrying and crushing. It is then dried and ground to a powder, and finally calcined by heating to 270-325 deg. F., which drives off all but about 5 per cent. of the water of crystallization. If all the water is expelled, the product is dead and will not set when mixed with water.

Texas.—The making of cement plaster from gypsite in Texas is a comparatively new industry that has grown to great proportions in a short time. Gypsite is a grayish-white substance largely composed of gypsum in a decomposed or disintegrated state. The physical condition of the gypsite gives the plaster manufacturers who use it a very decided advantage over those concerns in the North and East who use gypsum rock for making plaster, as the latter have to mine, crush and grind the rock, all expensive operations, before reaching the point arrived at by the gypsite user when he has simply plowed up the material. Plaster made from gypsite is commonly called cement plaster, as it possesses the adhesive, as well as some other qualities of portland cement; but, unlike portland cement, it is not hydraulic, and therefore it is not suitable for cisterns, dams or underground work; but for mortar, for brick and stone work above ground, and particularly for wall plaster, it is unsurpassed.

For several years past, Hardman county has enjoyed the distinction of furnishing the trade with more cement plaster than any other locality of the same area. There are three companies operating mills in this county, the Acme Cement Plaster Company, the American Cement Plaster Company, and the Texas Cement Plaster Company. The mill of the Acme company is situated at Acme, and is the largest cement plaster mill in the world. Next in point of size is the plant of the American company, situated one mile north of Acme. The mill of the Texas company is at Quanah. The combined capacity of the different mills of Hardeman county is 800 to 1000 tons per day. There are immense deposits of gypsite on Groesbeck creek, and it is safe to predict that, with the present rate of output, no person now engaged in the industry will live to see them worked out.

Gypsum Mining in Foreign Countries.

Canada.—The production of gypsum in Canada in 1909 amounted to 468,551 long tons, valued at $667,816, as compared with 340,964 tons worth $575,701 in 1908. Most of the output was derived from the provinces of Nova Scotia and New Brunswick, and was shipped in lump form to calcining mills in the United States. Small quantities were also mined in Manitoba and Ontario for home consumption. Total exports in 1909 were 315,201 long tons, valued at $372,286. Of the four producing provinces, Nova Scotia made the largest output. Approximately 85 per cent. of this production was derived from quarries at Windsor, Avondale, Walton, Cheverie, Noel, etc., in Hants county, the balance being mined at St. Anns, Victoria county, and Cheticamp, Inverness county. In Hants county the Wentworth Gypsum Company, operating near Windsor, was the largest producer, mining about 200,000 tons. The other principal operators were the Windsor Gypsum Company, the Windsor Plaster Company, the Noel Plaster Company, Albert Parson and Lorenzo Ettinger.

In 1909 there were only two companies engaged in quarrying gypsum in Cape Breton, namely, the Victoria Gypsum Mining and Manufacturing Company, operating at St. Anns, and the Great Northern Gypsum Company, which commenced the manufacture of selinite plaster at Cheticamp, Inverness county. The Victoria company ships its gypsum to the Keystone Gypsum Company, of Philadelphia. The maximum output of this company is about 50,000 tons per year, the present production being about one schoonerload of 1700 tons per fortnight. Formerly this company operated at Port Bevis, on Bras d'Or lake. Its present quarries are about three or four miles from the coast and are connected with its shipping piers by a steam railroad. The Albert Manufacturing Company, which operates at Hillsborough, New Brunswick, opened quarries at McKinnons harbor, on Bras d'Or lake in Victoria county, but as yet has not begun shipping from this point. Other important deposits of gypsum are known to occur in Isle Madame, Richmond county, at Little Narrows, near McKinnons harbor, at Port Hastings, Inverness county, and at Dingwall, Victoria county. These deposits are all of commercial value and occur at or near the seacoast.

The deposit at Dingwall, on Apsy bay, is of great size and rather typical of the deposits of Cape Breton. The gypsum is exposed along the shore of the harbors, along the course of the North Apsy river, and even in cuts along the road in great cliffs, rising in places to a hight of over 50 ft. In all, this deposit covers approximately five square miles of territory. Probably not more than one-third of this will produce marketable gypsum, as it contains a great quantity of anhydrite, no commercial use of which has as yet been found. The harbor at Dingwall is exceptionally well protected and commodious, but at present it is not accessible to boats of any size; therefore, this deposit can only be developed after the Government has opened up the harbor. The best quality of plaster occurs between Middle and North harbors, at some distance from the water's edge, so that short railroads will have to be used to transport the material to shipping piers. At Ingonish gypsum cliffs extend for almost half a mile along the coast of South harbor, and most of the way across a neck of land about half a mile wide, to North harbor. This deposit is not so large as the one at Dingwall, but is much more accessible, as the harbor at Ingonish is now open to schooners of light draft. The gypsum at Ingonish is for the most part of good quality, containing little anhydrite.

In New Brunswick the principal producer was the Albert Manufacturing Company, of Hillsborough. This firm runs a large mill for the manufacture of plaster of paris and ships its product throughout Canada. The Hillsboro Plaster Company operated a quarry at Hillsborough, and a small quantity of gypsum was mined by John E. Stuart from the Topique gypsum deposits in Victoria county.

In 1909 the principal producers in Ontario were the Alabastine Company, of Paris; the Imperial Plaster Company, of Toronto; and the Crown Gypsum Company, Ltd., of Oneida. The Alabastine company sells crushed and ground gypsum and manufactures plaster of paris and special wall finishes. The quarries of the Imperial company are at Cayuga.

In Manitoba the only operator was the Manitoba Gypsum Company, which has a mill and calcining works at Winnipeg. The quarry of the company is situated at the north end of Lake Manitoba, the rock being shipped over a narrow-gage railway from the mine to the lake, where it is transported by steamer to Totogan, on the head of the lake, and thence over the Canadian Northern Railroad to Winnipeg.

The gypsum produced in Nova Scotia and New Brunswick is of a superior character. It is of a fine quality, containing little iron or other substances which affect the color, and carries but small quantities of magnesia and calcium carbonate. The deposits are advantageously situated, in many cases directly on the seacoast, and in harbors where shipping facilities are good, or at least close enough to tide water so that the product of the quarries can be cheaply loaded on ships. Many of the deposits are of great extent and can be quarried at a low cost. Common labor is comparatively cheap, bringing only from $1.35 to $1.50 per day. Owing to these advantages of low labor costs and situation, operating companies are enabled to market their product at a profit for about $1.10 to $1.25 per ton f.o.b. shipping point. The freight charges to New York when handled in schooners or steamers especially devoted to this trade, usually run from $1.25 to $1.75 per ton. The gypsum must be shipped in lump form, for if there is a large percentage of fines the material becomes massed in the ship's hold and in some cases damage to the whole cargo ensues.

Owing to the reduction of the United States import duty on both crude and calcined gypsum, the gypsum industry is rapidly expanding in Canada, and there is no doubt that as the larger deposits in southern Nova Scotia and New Brunswick become depleted more attention will be directed to the available supplies on Cape Breton Island.

India.—An investigation of the deposits of selenite, discovered in the Hamirpur district of the United Provinces in 1908, has proved that the deposits are of no commercial importance, as they are shallow and cover areas of only a few hundred square yards. The gypsum is of secondary origin and was formed from limestone by the action of sulphuric acid derived from the oxidation of pyrite.

Newfoundland.—There are large deposits of gypsum at St. George bay and Codroy harbor. The deposits are fairly accessible and are of good quality. At Codroy the gypsum shows in cliffs 30 to 50 ft. high, extending for three-quarters of a mile along the shore.

PRODUCTION OF GYPSUM IN THE PRINCIPAL COUNTRIES. ((*a*)
(In metric tons.)

Year.	Algeria. (*b*)	Canada.	France. (*b*)	Germany. (*c*)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1896......	37,512	187,778	2,051,124	32,801	28,799	120	7,605	196,404	201,305
1897......	36,750	217,340	2,004.339	40,702	26,153	51	8,187	184,287	272,493
1898......	37,337	198,864	2,115,261	28,037	25,688	83	8,390	199,174	285,644
1899......	39.950	221,821	1,807,454	29,419	29,727	81	6,546	215,974	382,891
1900......	42,237	228,656	1.774,492	26,381	35,484	129	4,415	211,436	439,265
1901......	44,025	266,476	2,385,633	28,183	3,581	671	(*d*)	204,045	598,529
1902......	44,975	301,165	2,185,346	33,150	31,701	*Nil.*	(*d*)	228,264	740,906
1903......	41,550	285,242	1,998,804	29,423	30,894	94	(*d*)	223,426	945 285
1904......	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905......	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,626
1906......	27,950	378,904	1,377,429	25,643	50,763	70	(*e*) 5,000	228,627	1,397,480
1907......	26,400	431,286	1,316,567	29,153	48,975	70	(*e*) 5,000	247,537	1,564,061
1908......	31,875	346,436	1,750,562	35,217	51,314	(*d*)	(*e*) 5,000	231,980	1,694.155
1909......	(*d*)	476,071	(*d*)	36,621	51,630	(*d*)	(*e*) 5,000	242,832	(*d*)

(*a*) From official reports of the respective countries, except the statistics for the United States. (*b*) A part of the product is reported as plaster of paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (*c*) Prussia is a large producer of gypsum, but there are no complete statistics available. (*d*) Statistics not yet available. (*e*) Estimated.

IRON AND STEEL.

BY FREDERICK HOBART.

As the record of 1908 was one of deep depression at the beginning, with only slow and halting steps toward recovery in the later part of the year, that of 1909 began rather unfavorably. The determined adherence of the leading interests to the policy of maintaining prices seemed to have discouraged those who believed that the financial condition of the country had so far improved that money was ready for investment in construction of all kinds, if only proper encouragement could be given by the cheapening of material. Their view finally prevailed. The halting and confusion of the early months of the year fast gave way to activity on every side. Production increased by leaps and bounds, and the year closed with blast furnaces and steel mills operating at a rate unprecedented in the history of the tradė, and with preparations for increasing their capacity. Later experience proved that the extent of the recovery has been overestimated, and that production had been increased beyond the consuming power of the country. The result has been that a further period of reaction succeeded the great productive activity of the closing months of 1909.

IRON ORE.

The production of iron ore at the opening of 1909 was at a low level, and the estimates of the requirements for the year were not encouraging. It was not until work was well started for the season that it became apparent that these estimates were mistaken. It became necessary to call in all the reserves of labor and machinery and to extend operations in every direction in order to meet the demand. The Lake Superior region in particular was urged to the limit, and responded well, especially from the Mesabi range in Minnesota. The value of the exploration and development work done in 1907 and 1908 became apparent, and the monthly shipments in the latter part of the season were greater than any before known.

The southern iron ore mines were, like those of the Lake Superior region, in a condition to respond to a call for increased production. In the East there was a good deal of work done in extending old mines and in reopening deposits formerly worked. The Lake Champlain and

Adirondack regions in New York had much work of this kind done. The Wharton group and other mines in New Jersey were actively worked.

In the tables no account is made of stocks on hand, except the ore carried on lake docks, for the reason that accurate figures are not attainable for what may be called the invisible stocks; that is, those in furnace yards. It is probable that there was no great difference. At the opening of the year, furnaces were not disposed to carry large stocks; at its close they were hardly able to get the ore as fast as they needed it.

The consumption of iron ore per ton of pig iron made appears to be increasing, owing to the use of lower-grade ores. Last year it was about 2.10 tons.

IRON ORE MINED AND CONSUMED IN THE UNITED STATES.
(In tons of 2240 lb.)

District.	1903	1904	1905	1906	1907	1908	1909
Lake Superior..........	24,099,550	21,822,839	34,353,456	38,522,129	42,245,070	26,014,987	42,586,869
Southern States.........	5,889,000	5,450,000	7,175,000	7,450,000	7,585,000	5,900,000	7,350,000
Other States...........	2,483,000	2,190,000	3,050,000	3,265,000	3,125,000	1,875,000	3,150,000
Total..............	32,471,550	29,462,839	44,578,456	49,237,129	52,955,070	33,789,987	53,086,869
Add decrease in stocks..	703,169	....	....	....	....	....	....
Add imports...........	980,440	487,613	845,651	1,060,390	1,229,168	776,898	1,696,411
Total..............	34,155,159	29,950,452	45,424,107	50,297,519	54,284,238	34,566,885	54,783,280
Increase in stocks.......	....	....	....	....	3,750,000	750,000	521,000
Deduct exports.........	80,611	213,865	208,058	265,240	278,208	309,099	455,932
Total consumption..	34,074,548	29,736,587	45,216,049	50,032,279	50,256,030	33,507,786	53,806,204

Lake Superior Iron Ores.—The statistics of Lake Superior shipments are very closely kept, through the enterprise of the Cleveland *Iron Trade Review,* and are shown in the accompanying tables.

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR.
(In tons of 2240 lb.)

Range.	1904	1905	1906	1907	1908	1909
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Marquette..........	2,843,703	4,210,522	4,057,187	4,388,073	2,414,632	4,256,172
Menominee..........	3,074,848	4,495,451	5,109,088	4,964,728	2,679,156	4,875,385
Gogebic.............	2,398,287	3,705,207	3,643,514	3,637,907	2,699,856	4,088,057
Vermillion	1,283,513	1,677,185	1,792,355	1,685,267	841,544	1,108,215
Mesabi..............	12,152,008	20,153,699	23,792,553	27,492,949	17,257,350	8,176,281
Baraboo............	67,480	111,391	128,742	76,146	122,449	82,759

About 80 per cent. of the lake ore goes to the Lake Erie ports for distribution to the consuming furnaces. The remaining 20 per cent. goes chiefly to Chicago and vicinity for the furnaces of the Illinois Steel Company and others, and lately for the great new furnaces of the Indiana Steel Company at Gary.

PRODUCTION OF IRON ORE IN THE LAKE SUPERIOR DISTRICT.
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855........	1,449	1875...	881,166	1895...	10,429,037	1904...	21,822,839	1908...	26,014,987
1860........	114,401	1880...	1,948,334	1900...	19,059,393	1905...	34,353,456	1909...	42,586,869
1865........	193,758	1885...	2,466,642	1902...	27,562,566	1906...	38,522,239		
1870........	859,507	1890...	9,003,725	1903...	24,289,674	1907...	42,266,668		

LAKE SUPERIOR ORE SHIPMENTS TO END OF 1908.
(In tons of 2240 lb.)

Range.	Tons.	Per Cent.	Range.	Tons.	Per Cent.	Range.	Tons.	Per Cent.
Marquette ...	191,903,991	20.4	Gogebic......	60,820,503	13.5	Mesabi.......	195,703,424	43.5
Menominee ..	71,313,115	15.9	Vermillion....	29,125,385	6.5	Baraboo......	880,627	0.2

RECEIPTS AND STOCKS AT LAKE ERIE PORTS. (*a*)
(In tons of 2240 lb.)

Ports.	Receipts.			Stocks.		
	1907.	1908.	1909.	1907.	1908.	1909.
Toledo...........................	1,314,140	680,553	1,374,224	518,645	590,925	332,456
Sandusky.........................	83,043	....	11,088	44,546	36,079	39,557
Huron............................	971,430	213,377	243,082	415,730	458,158	477,333
Lorain...........................	2,621,025	2,286,388	2,796,856	366,271	426,274	407,129
Cleveland........................	6,495,998	4,240,816	6,051,342	1,281,335	1,458,392	1,547,142
Fairport.........................	2,437,649	1,518,961	1,734,277	523,981	835,821	867,640
Ashtabula........................	7,521,859	3,012,064	8,056,941	2,056,820	2,293,531	2,594,359
Conneaut.........................	5,875,937	4,798,631	7,007,834	1,090,774	1,296,675	1,411,002
Erie.............................	2,294,239	828,602	1,235,057	652,219	730,530	788,046
Buffalo..........................	5,580,438	2,835,099	5,002,235	435,407	315,148	501,125
Detroit..........................	....	....	159,889	....	....	....
Total............................	35,195,758	20,414,491	33,672,825	7,385,728	8,441,533	8,965,789

(*a*) Deliveries in 1909 to Lake Michigan ports: South Chicago, 4,673,810; Gary, 1,927,818; Milwaukee, 178,720; minor ports for local furnaces, 155,483; total, 6,929,831 tons.

The prices of Lake Superior ore to buyers for the season of 1909 were, f.o.b Lake Erie ports: Old Range bessemers, \$4.50; Mesabi bessemers, \$4.25; Old Range nonbessemers, \$3.70; Mesabi bessemers, \$3.50. The base guarantee was 55 per cent. iron for bessemer ore, and 51.5 per cent. for nonbessemer ore. All the larger steel companies own their mines, and to them, of course, the price of their ore is practically the cost of mining and transporting it.

Foreign Iron Ores.—Iron ore imports in 1909 included 927,774 tons from Cuba, 404,065 from Europe—chiefly Sweden and Spain—and 251,550 from Newfoundland. The total imports, as shown in the tables, were the largest ever reported.

For a number of years past the quantity of iron ore imported has averaged about 3 per cent. of the lake production, but in 1909 it was about 5 per cent. A careful study by B. S. Stephenson, in the Cleveland *Iron*

Trade Review puts the probable imports for 1910 at over 3,000,000 tons. On the basis of contracts known to have been already closed 1,500,000 tons of ore are to come from Cuba; 700,000 tons from Spain; 300,000 from Sweden; 100,000 from Algeria; 50,000 from Greece, and 350,000 tons from Newfoundland. Cuba and Newfoundland are familiar sources of supply; Spain also to a smaller extent. Sweden and Algeria, however, are comparatively new fields, so far as our ironmakers are concerned. A large part of the Cuban ore is taken by the Bethlehem and the Pennsylvania Steel companies, which control the deposits in the island; but there is a surplus for sale to eastern merchant furnaces, of a quality which will take the place of the more expensive lake ores.

Two causes contribute to this increased importation, besides the higher cost of lake ores. One is the reduction of the duty on iron ores from 40c to 15c.—or to 12c. in the case of Cuban ores. Another is that ocean freights are low, and promise to continue so for some time. Moreover, the ocean transportation of ore has been in recent years reduced to a system and improved by the use of steamers especially built for the trade, on plans approaching as nearly as ocean conditions will permit our large lake ore carriers. The Cuban mines and the larger Swedish and Spanish mines now control their own fleets, and can contract for deliveries without reckoning with possible variations in freight rates.

A peculiar feature in the trade was the closing of a contract for the importation of iron ores from China.

The Western Steel Corporation of Seattle, Wash., made a contract calling for a minimum of 36,000 tons each of ore and pig iron for the first two years, and after that for 200,000 tons a year. The contract includes the option of renewal at the expiration of 15 years.

The Chinese ore is a hematite, containing 66 per cent. of iron, with just a trace of sulphur and phosphorus. This ore is to be mixed with equal amounts of British Columbia and Washington iron ores. The pig iron will be mixed with the pig iron made at Irondale, and used in making high-grade steel of all kinds.

Pig Iron Production.

The production in the first half of 1909 showed a considerable increase over the second half of 1908, though it was still below that of either half of 1907. For the second half of 1909 the complete figures collected by the American Iron and Steel Association put the make of pig iron at 14,773,125 long tons. The great production of the second half brought the total for 1909 up to 14,110 tons above that of 1907, making it the greatest of any year in our history.

The drop of 9,860,000 tons in production in one year—from 1907 to

PIG IRON PRODUCTION OF THE UNITED STATES.
(In tons of 2240 lb.)

Kind of Iron.	1903	1904	1905	1906	1907	1908	1909
Foundry and forge...	5,281,200	4,358,295	5,837,174	5,709,350	6,397,777	4,307,734	6,386,833
Bessemer pig........	9,989,908	9,098,659	12,407,116	13,840,518	13,231,620	7,216,976	10,557,370
Basic pig...........	2,040,726	2,483,104	4,105,179	5,018,674	5,375,219	4,010,144	8,250,225
Charcoal............	504,757	337,529	352,928	433,007	437,397	249,146	376,003
Spiegel and ferro.....	192,661	219,446	289,983	300,500	339,348	152,018	225,040
Total........	18,009,252	16,497,380	22,992,380	25,302,049	25,781,361	15,936,018	25,795,471

PIG IRON PRODUCTION ACCORDING TO THE FUEL USED.
(In tons of 2240 lb.)

Fuel used.	1903	1904	1905	1906	1907	1908	1909
Coke (*a*)............	15,592,221	14,931,364	20,964,937	23,313,498	23,972,410	15,331,863	24,721,037
Anthracite and coke .	1,911,347	1,228,140	1,674,515	1,535,614	1,335,286	318,741	682,383
Anthracite alone.....				25,072	36,268	36,268	16,048
Charcoal............	504,757	337,529	352,928	433,007	(*b*) 437,397	(*b*)249,146	(*b*) 376,003
Charcoal and coke...	927						
Total..........	18,009,252	16,497,033	22,992,380	25,307,191	25,781,361	15,936,018	25,795,471

(*a*) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke. (*b*) Includes a small quantity made by the electric furnace.

PRODUCTION OF PIG IRON BY DISTRICTS.
(In tons of 2240 lb.)

	1904.	1905.	1906.	1907.	1908.	1909.
N. England, N. Y. and N. J........	880,074	1,525,094	1,952,288	2,052,060	1,258,661	2,046,537
Pennsylvania......................	7,644,321	10,579,127	11,247,869	11,348,549	6,987,191	10,918,824
Ohio, Ill., Mich., Wis. and Minn.....	5,077,549	7,260,712	8,226,778	8,467,045	5,050,303	9,331,166
Maryland..........................	293,441	332,096	386,709	411,833	183,502	286,856
Southern States...................	2,449,872	2,887,577	3,080,507	3,033,388	2,143,290	2,829,321
West of the Mississippi............	151,776	407,774	413,040	468,486	313,071	382,767
Total..........................	16,497,033	22,992,380	25,307,191	25,781,361	15,936,018	25,795,451

PRODUCTION OF PIG IRON BY STATES.
(In tons of 2240 lb.)

States.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Massachusetts.......	3,265	3,149	15,987	20,239	19,119	13,794	18,388
Connecticut.........	14,501	8,922					
New York...........	552,917	605,709	1,198,068	1,552,659	1,659,752	1,019,425	1,733,675
New Jersey..........	211,667	262,294	311,039	379,390	373,189	225,372	294,474
Pennsylvania........	8,211,500	7,644,321	10,579,127	11,247,869	11,348,549	6,987,191	10,918,824
Maryland...........	324,570	293,441	322,096	386,709	411,833	183,502	286,856
Virginia............	544,034	310,526	510,210	483,525	478,771	320,458	391,134
Alabama............	1,561,398	1,453,513	1,604,062	1,674,848	1,686,674	1,397,014	1 763,617
N. Carolina & Georgia	75,602	70,156	38,699	92,599	55,825	24,345	26,072
Texas..............	11,653	5,530					
West Virginia.......	199,013	270,945	298,179	304,534	291,066	65,551	228,282
Kentucky...........	102,441	37,106	63,735	98,127	127,946	45,096	86,371
Tennessee...........	418,368	302,096	372,692	426,874	393,106	290,826	333,845
Ohio...............	3,287,434	2,977,929	4,586,110	5,327,133	5,250,687	2,861,325	5,551,545
Illinois.............	1,692,375	1,655,991	2,034,483	2,156,866	2,457,768	1,691,944	2,467,155
Michigan............	244,709	233,225	288,704	369,456	(*a*)436,507	(*a*)348,096	(*a*)964,289
Wisconsin & Minn....	283,536	210,404	351,415	373,323	322,083	148,938	348,177
W. of Miss. Riv......	270,289	151,776	407,774	413,040	468,486	313,071	382,767
Total.............	18,009,252	16,497,033	22,992,380	25,307,191	25,781,361	15,936,018	25,795,471

(*a*) Includes Indiana.

CONSUMPTION OF PIG IRON IN THE UNITED STATES.

(In tons of 2240 lb.)

	1905	1906	1907	1908	1909
Production	22,992,380	25,307,091	25,781,361	15,936,018	25,795,471
Imports	212,465	379,828	489,440	92,202	174,988
Total	23,204,845	25,686,919	26,270,801	16,028,220	25,970,459
Exports	49,221	83,717	73,844	46,696	61,999
Approximate consumption	23,155,624	25,603,202	26,196,957	15,981,524	25,908,460

1908—was an extraordinary fluctuation, far greater than had ever before occurred. The loss was greater than the entire output of Great Britain, and greater than our own entire yearly production only a few years ago. Usually in the past when a crisis in the trade has brought about a large decrease, it has taken two or three years to return to the high point. This time the recovery was made in a single year, showing an equally extraordinary change.

A gain can be made if the demand warrants it. The production of the second half of 1909 was at the rate of 29,500,000 tons a year; and with the existing blast-furnace capacity this can be increased to 36,000,000 tons, if the iron is needed.

The details of the production are given in the accompanying tables, which—like the others given for United States production—are based upon the figures collected and published by the American Iron and Steel Association. The membership of that association and the long experience of its general manager, James M. Swank, make its statistics the final and unquestioned authority.

Steel Production.

The production of steel in 1909, like that of pig iron, showed a most remarkable recovery from the depression of 1908, and was the largest ever reported in a single year. The details are shown in the accompanying tables. The year again showed an increase in the proportion of open-hearth steel to the total make, though the output of bessemer steel is still large.

PRODUCTION OF STEEL IN THE UNITED STATES.

(In tons of 2240 lb.)

Kinds.	1903	1904	1905	1906	1907	1908	1909
Bessemer	8,577,228	7,859,140	10,941,375	12,275,830	11,667,549	6,116,755	9,330,783
Open-hearth	5,837,789	5,908,166	8,971,376	10,980,413	11,549,088	7,836,729	14,493,936
Crucible and special	112,238	92,581	111,196	141,893	145,309	69,763	130,302
Total tons	14,527,255	13,859,887	20,023,947	23,398,136	23,361,946	14,023,247	23,955,021
Total metric tons	14,756,691	14,081,645	20,344,330	23,772,506	23,735,737	14,247,618	24,338,301

GEOGRAPHICAL DISTRIBUTION OF THE STEEL PRODUCTION IN 1907 AND 1908. (a)

	1908			1909		
	Bessemer.	Open-hearth.	Total.	Bessemer.	Open-hearth.	Total.
Pennsylvania.......	2,106,382	5,322,229	7,428,611	2,845,602	9,400,287	12,245,889
Ohio..............	1,955,446	525,171	2,480,617	3,466,077	1,424,452	4,890,529
Illinois and Ind....	1,237,747	483,104	1,720,851	1,632,444	1,836,529	4,468,973
Other States.......	817,180	1,506,225	2,323,405	1,386,660	1,832,668	3,219,328
Total........	6,116,755	7,836,729	13,953,484	9,330,783	14,493,936	23,824,719

(a) Disregarding the small quantity of crucible steel. In addition to the States named in the table, Massachusetts, Connecticut, New York, New Jersey, Delaware, Maryland, District of Columbia, Virginia, West Virginia, Kentucky, Michigan, Wisconsin, Minnesota, Missouri, Colorado, and Oregon made steel ingots or castings in 1908 by the standard bessemer process or by modified bessemer processes.

STEEL PRODUCTION FOR 12 YEARS.
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Converter.		Open-hearth.		Crucible, etc.		Total		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1898	6,609,017	74.0	660,880	7.4	93,548	1.0	7,363,445	82.4	1,569,412	17.6	8,932,857
1899	7,586,354	71.3	866,890	8.1	106,187	1.0	8,559,431	80.4	2,080,426	19.6	10,639,857
1900	6,684,770	65.6	853,044	8.4	105,424	1.0	7,643,238	75.0	2,545,091	25.0	10,188,329
1901	8,713,302	64.7	1,037,316	7.7	103,984	0.7	9,854,602	73.1	3,618,993	26.9	13,473,595
1902	9,138,363	61.2	1,191,196	8.0	121,158	0.7	10,450,717	69.9	4,496,533	30.1	14,947,250
1903	8,592,829	59.1	1,094,998	7.5	112,238	0.8	9,800,065	67.4	4,734,913	32.6	14,534,978
1904	7,859,140	56.7	801,799	5.8	92,581	0.7	8,755,520	63.2	5,106,367	36.8	13,859,887
1905	10,941,375	54.6	1,155,648	5.8	111,196	0.6	12,208,219	61.0	7,815,728	39.0	20,023,947
1906	12,275,830	52.5	1,321,653	5.6	141,893	0.6	13,739,376	58.7	9,658,760	41.3	23,398,136
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,634	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021

The open-hearth production approached closely to that of bessemer or converter steel in 1907, and in 1908 it exceeded it. The proportion of bessemer steel has fallen from 65.6 per cent. in 1900 to 39 in 1909; while that of open-hearth has risen from 33.4 to 60.5 per cent. The proportion of crucible steel was 1.03 per cent. in 1900; since then it has been always under 1 per cent., and in 1909 it was 0.5 per cent.

Included in the steel ingots and castings made in 1909 were about 182,000 tons of alloyed steel, of which 159,000 tons were ingots and 23,000 tons castings. Of the total of 182,000 tons approximately 42,000 tons were made in bessemer converters, 120,000 tons in open-hearth furnaces and 20,000 tons in crucible, electric or special furnaces.

All the bessemer or converter steel made in the United States is acid steel; the basic converter is not used. Of the open-hearth steel in 1909 by far the larger part—92.6 per cent. of the total—was basic steel; only 7.4 per cent. being made by the acid process.

Steel Production of Leading Countries.—The United States and Germany are the two chief steel producers, making together about

STEEL PRODUCTION OF PRINCIPAL COUNTRIES.
(In metric tons.)

Kind of Steel.	1907		1908		1909	
	United States	Germany.	United States	Germany	United States	Germany.
Acid converter	11,854,230	387,120	6,214,623	374,100	9,480,076	151,148
Basic converter	....	7,212,454	....	6,510,754	....	7,517,451
Total converter	11,854,230	7,599,574	6,214,623	6,884,854	9,480.076	7,668,599
Acid open-hearth	1,290,089	212,620	707,445	224,211	1,093,687	311,812
Basic open-hearth	10,443,784	4,039,940	7,254,672	3,969,595	13,632,152	3,967,581
Total open-hearth	11,733,873	4,252,560	8,062,117	4,193,806	14,724,839 109,072	4,279,393 84,069
Crucible	147,634	211,498	64,649	88,183	23,314	17,773
Electric, etc	....	....	6,230	19,536	....	....
Total	23,735,737	12,063,632	14,247,619	11,186,379	24,338 301	12,049.834
Proportions steel to pig iron	90.6	92.5	88.0	94.6	92.9	93.3

MAKE OF ACID AND BASIC STEEL.
(In metric tons)

	1907		1908		1909	
	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.
United States	12,937,322	10,279,315	6,992,947	7,254,672	10,706,149	13,632,152
Germany	674,371	11,199,282	706,030	10,480,349	564,802	11,485,032
Total	13,611,693	21,478,597	7,698,977	17,735,019	10,270,951	25,117,184

67 per cent. of the world's total. The comparison of their steel production given in the tables is, therefore, of much interest. The differences in practice are due chiefly to the nature of the iron ore supplies upon which the industries of the two countries are based. The American production of basic steel may be expected to increase as the supply of low-phosphorus ores continues to decrease.

Finished Iron and Steel.—The production of rails in the United States in 1909 was rather larger than had been expected. It reached a total of 3,062,582 tons, which was 1,140,971 tons more than in 1908, but 601,043 tons less than in 1907. It was less by 915,315 tons than in 1906, when our maximum production of rails was reached.

The remarkable point in the rail production of 1909 was the great increase in the make of open-hearth steel rails. The long discussion, extending over two years, of the defects of bessemer-steel rails resulted in a general turning to the open-hearth furnace as a producer of rail metal. In 1909 the make of open-hearth steel rails was 1,255,961 tons, which was two and one-half times that of 1908, and five times that of

1907. The proportion of bessemer-steel rails fell from 93 per cent. of the total in 1907 to 70.5 per cent. in 1908 and to 60 per cent. in 1909. It is not unlikely that it will be below 50 per cent. in 1910. Up to 1909 the greater part of the open-hearth rails were made in Alabama, at the Ensley works of the Tennessee Coal, Iron and Railroad Company; in 1909 Indiana and Pennsylvania both exceeded Alabama in their production.

The statistics of output by sections show that in 1909 only 8.4 per cent. of the rails made were under 45 lb per yard; 34 per cent. were between 45 and 85 lb; while 57.6 per cent. were 85 lb or over. Open-hearth steel went largely into the heavier sections; it was used in 52 per cent. of the rails over 85 lb; in 29.4 per cent. of the medium sections, and in only 12.5 per cent. of the light rails.

An interesting statement—the first report of the kind ever made—is that 50,505 tons of alloyed-steel rails were made. In these titanium steel led, nickel-chrome coming next. There were only small quantities of nickel-steel and manganese steel.

The iron-rail industry has disappeared. In 1907 there were 925 tons of iron rails made; in 1908 only 71 tons, and in 1909 none at all. In recent years the only iron rails made were of very light section, for mine and industrial use.

RAIL PRODUCTION IN THE UNITED STATES.

(In tons of 2240 lb.)

Material.	1907	1908	1909	Section.	1907	1908	1909
Bessemer Steel...	3,380,025	1,354,236	1,806,621	Under 45 lb...	295,838	183,869	255,858
Open-hearth Steel	252,704	567,304	1,255,961	45 to 85 lb....	1,569,985	688,198	1,041,184
Iron.............	925	71	....	Over 85 lb....	1,767,831	1,049,544	1,765,540
Total........	3,633,654	1,921,611	3,062,582	Total......	3,633,654	1,921,611	3,062,582

The American Iron and Steel Association gives the production of structural shapes in the United States in 1909 at 2,275,562 tons, the largest quantity ever reported. The totals for 10 years are given in the accompanying table.

STRUCTURAL STEEL IN THE UNITED STATES.

(In tons of 2240 lb.)

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1900....	815,161	1902...	1,300,326	1904...	949,146	1906...	2,118,772	1908...	1,083,181
1901....	101,350	1903...	1,095,813	1905...	1,660,519	1907...	1,940,852	1909...	2,275,562

These statistics do not include plates, girders made from plates, or bars for reinforcing concrete work. Plates and concrete bars are provided for under other classifications, and all plates cut to specifications are included in the general statistics of plates.

Changes and Consolidations.

Changes among iron and steel companies were comparatively few; and no consolidations of great importance were made. There was at one time talk of a consolidation of several of the larger independent companies, but this was rumor only, and nothing resulted. The Bethlehem Steel Corporation extended its operations in this country and its mining interests in Cuba, and absorbed some of its subsidiary companies. Near the close of the year the Rogers-Brown Iron Company was organized, taking in the Buffalo & Susquehanna Iron Company and some allied interests.

Since the close of the year the Steel Corporation has increased its ore holdings in the Michigan iron ranges by the purchase of 440,000 acres from the Michigan Iron and Land Company. Nearly half this area is known or probable ore land.

Probably the most important event of the year was the progress made on the extensive works of the United States Steel Corporation at Gary, Ind. Several of the blast furnaces and some units of the steel plant are now in operation, and rapid progress is being made with the rest. Important improvements have been in progress at the steel works of the Tennessee Coal, Iron and Railroad Company at Ensley, Ala. These will enlarge the capacity of the works, and it is intended to handle there all the Steel Corporation business in the South. The Jones & Laughlin Steel Company resumed work on its new plant at Allequippa, Penn., and has the blast furnaces there now in operation. The new mills of the Bethlehem Steel Company, near Bethlehem, Penn., are nearing completion.

Technical Progress.

The progress of the open-hearth steel production was marked, though no very great changes occurred in 1909. Both the Gary and Ensley plants are open-hearth steel works, and no new bessemer converters are being installed. Further investigations of the quality and properties of steel were in progress, but with no announced results.

The Gary dry-air blast has made progress both in the United States and abroad. Mr. Gary has supplemented it by devices intended to secure uniformity of temperature in the blast and consequently of the weight of air delivered to a furnace.

The electric furnace continued to make progress, especially in the manufacture of steel. The Steel Corporation installed two electric furnaces of large capacity, one at the Joliet works of the Illinois Steel Company and the other at the wire works at Worcester, Mass.

The Electric Furnace.—A list recently compiled by *Stahl und Eisen* names 114 electric furnaces in existence or nearly completed for the making of steel, besides seven used in making pig iron. The pig-iron furnaces include one furnace of 2500 tons yearly capacity at Domnavfvet, and one of 7500 tons at Trollhattan in Sweden; two of 7500 tons yearly capacity in Norway. In America there are three, all of the Heroult type; one at Welland and one at Sault Ste. Marie, Ontario; and one at Heroult on the Pitt river in California. All of these are operated by water-power.

Of the 114 steel furnaces, 77 are arc furnaces, 35 induction and two combination. The Heroult type leads with 29 furnaces; there are 17 Girod, 13 Stassano, six Keller, and five Chaplet furnaces at work; also four designed by the Aktiebolaget Elektrometal Ludvika in Sweden. Lastly, there are three furnaces with special modifications.

Of the 35 induction furnaces, 15 of the Röchling-Rodenhauser type are found; 14 Kjellin furnaces; two furnaces of the Kjellin-Colby type. A furnace of the Frick type is operating; one each of the Schneider, the St. Jacques and the Hiorth types.

Finally there are two Nathusius combination furnaces, both in Germany.

Distributing the total geographically, Germany leads with 31 furnaces, France coming next with 22. Italy has 12, Austria and the United States, each, 10; England has seven; Sweden, five; Canada, Belgium and Mexico three each. Russia, Norway and Switzerland each has two furnaces; Spain and Brazil, each one. The Röchling-Rodenhauser and the Heroult types find most favor in Germany; the Keller and the Chaplet in France; the Stassano in Italy, and the Heroult in the United States. The larger number of projected new furnaces are found in Sweden and Canada, as might be expected in countries where water-power is abundant, and fuel has to be imported.

Labor Conditions.

With two exceptions the year 1909 was measurably free from labor troubles in the iron and steel trades. A strike at the works of the Pressed Steel Car Company at McKees Rocks, Penn., was the cause of much trouble and a great deal of violence; but it was local in its causes and effects and did not extend further.

In June, according to custom, the Amalgamated Association of Iron, Steel and Tin Workers presented a new scale to the manufacturers. This association is one of the oldest labor unions in the country and its members are in the bar, sheet and tinplate mills. After some discussion and amendment the scales were adopted by the Republic Iron and Steel Company and by the independent manufacturers. The American Sheet and Tin Plate Company, however, refused to sign any agreement, announcing its intention of operating all its plants on the open-shop plan. This resulted in the closing of several of the mills which had been union works. The company was able to go on with its non-union works, and to reopen some of the former union mills, so that its operations were not seriously affected. The cause of the Amalgamated Association was taken up at the annual convention of the American Federation of Labor, and a formal declaration of hostility to the United States Steel Corporation was the result. No actual steps have been taken, but the Federation has begun the collection of a large reserve fund, to be used when opportunity for a strike is presented. The strike failed entirely and all the plants of the American Company are now operated on the open-shop plan.

Foreign Trade.

Exports and imports of the United States did not show any marked changes in 1909; they are given in the accompanying tables. The changes in quantities were greater than in value, owing to a generally lower level of declared values. The increase was pretty well distributed, taking in rails, bars, plates, wire and billets. The increase in billets was chiefly due to a large contract for tinplate bars for Welsh works, taken early in the year.

A marked feature of the imports was a large increase in structural steel, most of which was brought in on the Pacific Coast. Deliveries of foreign steel are made there by water, at a low freight rate, while the high rail rates from the East offset the duty charged. San Francisco especially has been using large quantities of structural steel in the rebuilding of the city, and constructors have found it to their advantage to take English, German and Belgian steel, rather than that from the East. There is also a strong local feeling involved on account of the refusal of the railroads to reduce rates on this class of material.

The tariff bill passed in August cut down the duties on pig iron, steel rails and a few other articles. Outside of these it did not make material changes. The reductions were not sufficient to induce any imports on a considerable scale. The imports of structural steel above referred to were the result of special and local causes, and the effect of tariff changes so far has been moderate. The exports did not increase to any great extent, although efforts were made to push them in the earlier part of the year. As business began to improve abroad, it increased still more rapidly here, and there was comparatively little surplus for export. The result serves to emphasize the remarks on foreign trade which were made in the review for the year 1908. The exports for 1909 included a large quantity of material for the Panama canal.

IRON AND STEEL EXPORTS AND IMPORTS, UNITED STATES.
TOTAL VALUE. (*a*)

	1904	1905	1906	1907	1908	1909
Exports	$128,455,613	$142,928,513	$172,555,588	$197,036,781	$151,113,114	$157,680,331
Imports	21,621,970	26,392,728	34,827,132	38,789,992	19,957,261	30,576,586
Excess, exports	$106,833,643	$116,535,785	$137,728,456	$158,246,789	$131,155,853	$127,163,745

(*a*) Including machinery.

UNITED STATES EXPORTS OF IRON AND STEEL.
(In tons of 2240 lb.)

	1902	1903	1904	1905	1906	1907	1908	1909
Pig iron	27,487	20,379	49,025	49,221	83,317	73,844	46,696	61,999
Billets, blooms, etc	2,409	5,445	314,324	237,638	192,616	79,991	112,177	104,862
Bars	31,549	37,182	55,472	51,870	88,102	98,654	46,103	87,960
Rails	67,455	30,656	414,845	295,023	328,036	338,906	196,510	299,540
Sheets and plates	18,300	18,093	55,204	75,034	110,654	122,696	104,993	180,048
Structural steel	53,859	30,641	55,514	83,193	112,555	138,442	116,878	90,830
Wire	97,843	108,521	118,581	142,601	174,014	161,228	136,167	149,341
Wire-rods	24,613	22,360	20,073	6,514	5,896	10,653	7,412	20,142
Nails and spikes	35,994	42,664	45,112	47,756	59,491	56,826	38,906	48,055
Pipe and fitting	....	....	....	....	....	176,832	114,371	162,140

UNITED STATES IMPORTS OF IRON AND STEEL.
(In tons of 2240 lb.)

	1902	1903	1904	1905	1906	1907	1908	1909
Pig iron	625,383	599,574	79,500	212,465	379,828	489,440	92,202	174,988
Billets, blooms, etc.	289,318	261,570	10,807	14,637	21,337	19,334	12,112	19,913
Scrap iron and steel	109,510	82,921	13,461	23,731	19,091	27,687	5,090	63,504
Bars	28,844	43,393	20,905	37,298	35,793	39,746	19,672	19,206
Rails	63,522	95,555	37,776	17,278	4,943	3,752	1,719	1,513
Wire-rods	21,382	20,836	16,206	17,616	17,999	17,076	11,208	10,544
Tinplates	60,115	47,360	71,304	65,740	56,983	57,773	58,320	62.593

THE UNITED STATES STEEL CORPORATION.

The Steel Corporation continued to be the most important factor, producing about 60 per cent. of the total output of finished material. Its managers were forced to give way in their chosen policy of limited output and high prices, but they did so in a way which preserved their influence in the trade. The earnings of the corporation showed an increase of between 30 and 40 per cent. over those of 1908. Condensed statements of operations are given in the accompanying tables. As might have been expected, the operations showed a large increase over

1908; the gross receipts having been $653,200,250 in 1909, or 34 per cent. greater than those of the preceding year. They were, however, 14.6 per cent. less than those of 1907. The difference in the surplus over all expenses was greater in proportion, the total of $131,491,414 being 43.2 per cent. more than in 1908, and 18.3 per cent. less than in 1907. The differences in production, on the other hand, were slightly less than those in earnings, a result of the comparatively lower prices prevailing over nearly three-quarters of the year. While 1907 was a boom year almost up to its close, and 1908 was a lean year throughout, 1909 was a year of mixed results; the first half having shown rather poor earnings, so that the gains reported were made almost entirely in the second half.

While noting these facts, it is a little curious that the report makes no specific reference to what was undoubtedly one of the chief moving causes for the improvement of the latter half—the reduction in prices and the opening of the market to general competition. The report refers only in a few lines to the lower prices made. It was, perhaps, hardly to be expected that much would be said as to the failure of a policy so long and persistently carried out and the success following its reversal. Taking the entire year the average decrease in prices, as compared with 1908, was 14.3 per cent. on domestic sales and 7.8 per cent. on export business. By the end of the year, owing to the increase in business, prices had nearly regained the reduction made early in the year. But it is to be noted that the advances were the normal result of an active demand, not the maintenance of an arbitrary level.

The corporation is primarily a maker of finished steel products, and those are the forms in which, mainly, its output reaches the consumer. Its sales of other products are incidental, and in the nature of disposal of by-products. Thus in pig iron—which has always been its weaker side—it has always been a buyer rather than a seller; and it never had much, or any, pig to sell until after it acquired the merchant furnaces of the Tennessee company. Even those are gradually being turned from foundry iron to basic pig for the supply of its new steel furnaces. The total output of finished steel in 1909 was 9,859,660 tons; the total sales and deliveries to consumers were 9,691,990 tons. Of these deliveries 89.7 per cent. were to domestic buyers and 10.3 per cent. were exported; the increase over 1908 being 57.9 per cent. in domestic sales and 28.8 per cent. in the exports. The latter were the largest ever reported, slightly exceeding a million tons.

In the manufacture of steel there was a notable change, due chiefly to the opening of the Gary plant and the extensions at Ensley. Passing over 1908 as an exceptional year, we find that in 1907 the proportion of bessemer steel made was 56.6 per cent. of the total, and of open-hearth, 43.4; while in 1909 the proportions were 43.8 converter and 56.2 open-hearth—almost exactly reversed.

At the close of 1909 the corporation owned 143 separate manufacturing plants, several of them of great size. Its iron-ore properties included 42 developed mines in the Lake Superior region and 21 in Alabama. Its coal holdings covered 180,572 acres in Pennsylvania, West Virginia, Indiana and Illinois, with 98 operating mines; and 335,336 acres, with 24 open mines, in Alabama. In Pennsylvania, West Virginia and Illinois, it had 75 coke plants, with 23,084 beehive and 612 by-product ovens; in Alabama seven coking plants with 2974 beehive ovens.

U. S. STEEL CORPORATION: GENERAL BALANCE SHEET.

Liabilities.		Assets.	
Capital stock (*a*)	$869,202,602	Property accounts	$1,502,445,244
Bonded debt	609,147,905	Sinking and reserve funds	21,738,953
Current liabilities	61,144,726	Deferred charges to operation	6,763,191
Sinking and reserve funds	114,735,986	Current assets and cash	291,018,167
Appropriations expended	16,379,808		
Undivided surplus	151,354,528		
Total	$1,821,965,555	Total	$1,821,965,155

(*a*) Stock includes $390,281,100 preferred; $508,302,500 common stock; $619,002 stocks of subsidiary companies not owned by the Steel Corporation.

U. S. STEEL CORPORATION: SUMMARY OF INCOME ACCOUNT.

	1907	1908	1909		1907	1908	1909
Gross sales	$757,014,768	$482,307,840	$646,382,251	Interest, etc. (*a*).	$27,719,744	$29,153,815	$30,423,665
Interest, etc	9,748,951	5,786,885	6,817,999	Depreciation	28,679,366	16,965,182	21,994,054
Total receipts	$766,763,719	$488,094,725	$653,200,250	Total	$56,399,110	$46,118,997	$52,417,719
Operating exp	$564,166,767	$367,735,102	$483,417,842	Surplus	$104,565,564	$45,728,714	$79,073,695
General expenses	25,395,379	21,001,037	27,786,420	Dividends	35,385,727	35,385,727	45,551,777
Sub. Co. accts	16,236,899	7,510,875	10,504,474	New Construct.	54,000,000	....	18,200,000
Total expense	$605,799,045	$396,247,014	521,708,836	Total expense	$89,385,727	$35,385,727	$63,751,777
Net earnings	$160,964,674	$91,847,711	$131,491,414	Undivided pfts.	$15,179,837	$10,342,987	$15,321,918

(*a*) Interest charges include sinking funds.

The corporation is, apart from its other interests, a transportation company of some importance, operating 1914 miles of road, equipped with 1024 locomotives and 45,224 cars. On the water it owns 77 steamers and 121 barges, a number of the steamships being of large size. Moreover, at the end of the year it had contracts let for 49 additional locomotives, 4900 cars and five steamships having a capacity for 12,500 tons of iron ore each. This transportation alone constitutes a considerable business, but is a necessary adjunct to the other activities.

PRODUCTION OF THE U. S. STEEL CORPORATION.
Including Tennessee Company in 1907, 1908 and 1909

	1904	1905	1906	1907	1908	1909
Iron Ore Mined—	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
From Marquette Range	934,512	1,359,722	1,442,290	1,170,496	830,087	899,002
From Menominee Range	1,186,104	1,871,979	1,874.680	1,625,358	1,021,598	1,359,415
From Gogebic Range	1,271,831	1,671,747	1,465.375	1,425,457	1,078,025	1,312,701
From Vermillion Range	1,056,430	1,578,626	1,794,186	1,724,217	927,206	1,066,474
From Mesabi Range	6,054,210	12,004,482	14,068,617	16,458,273	11,272,397	16,968,592
In Southern Region	....	....	....	1,576,757	1,533,402	1,824,863
Total	10,503,087	18,486,556	20.645,148	23,980,558	16,662,715	23,431,047
Coke Manufactured (a)	8,652,293	12,242,909	13,295,075	13,544,764	8,169,931	13,590,112
Coal Mined, not used in making coke	1,998,000	2,204,950	1,912,144	3,550,510	3,008,810	3,089,021
Limestone Quarried	1,393,149	1,967,355	2,227,436	3,201,222	2,186,007	3.496,071
Blast Furnace Products—						
Pig iron	7,210,248	9,940,799	11,058,526	11,234,447	6,810,831	11,436,570
Spiegel	100,025	158,071	150,044	130,554	74,716	80,942
Ferro-Manganese and Silicon	59,148	73,278	58,807	57,794	48,861	100,838
Total	7,369,421	10,172,148	11,267,377	11,422,795	6,934,408	11,618,350
Steel Ingot Production—						
Bessemer Ingots	5,427,979	7,379,188	8,072,655	7,556,460	4,055,275	5,846,300
Open-Hearth Ingots	2,978,399	4,616,051	5,438,494	5,786,532	3,783,438	7,508,889
Total	8,406,378	11,995,239	13,511,149	13,342,992	7,838,713	13,355,189
Rolled and Other Finished Products for Sale—						
Steel Rails	1,242,646	1,727,055	1,982,042	1,879,985	1,050,389	1,719,486
Blooms, Billets, Slabs, Tinplate Bars	932,029	1,253,682	1,096,727	761,195	551,106	675,614
Plates	404,422	780,717	836,399	894,364	312,470	729,790
Heavy Structural Shapes	313,779	484,048	620,823	587,954	313,733	658,516
Merchant Steel, Skelp, Hoops, Bands	577,384	982,782	1,240,548	1,338,833	577.591	1,290,970
Tubing and Pipe	710,765	911,346	1,025,913	1,174,629	654,428	1,013,071
Rods	84,934	84,049	·111,488	126,095	93,406	139,149
Wire and Products of Wire	1,226,610	1,283,943	1,399,717	1,481,226	1,275,785	1,607,689
Sheets—Black, Galvanized and Tinplate	757,482	924,439	1.112,542	1,070,752	770,321	1,024,985
Finished Structural Work	357,488	404,732	643,622	719,887	403,832	530,766
Angle and Splice Bars and Joints	72,470	150,265	176,730	195,157	84,669	190,226
Spikes, Bolts, Nuts and Rivets	46,003	61,496	70,233	67,991	40,252	72,076
Axles	62,981	149,596	181,913	189,006	24,057	68,366
Sundry Iron and Steel Products	25,787	28,236	79,736	77,463	54,893	138,956
Total	6,792,780	9,226,386	10,578,433	10,564,537	6,206,932	9,859,660
Spelter	29,963	29,781	28,884	31,454	28,057	27,853
Copperas (Sulphate of Iron)	15,805	20,040	21,933	24,540	26,411	33,582
	Bbl.	*Bbl.*	*Bbl.*	*Bbl.*	*Bbl.*	*Bbl.*
Universal Portland Cement	539,951	1,735,343	2,076,000	2,129,700	4,535,300	5,786,000

(*a*) Includes 828,751 tons made in by-product ovens in 1907; 578,869 in 1908, and 1,693,901 in 1909,

The army of employees grew from 165,211 reported in 1908, to 195,500 in 1909, an increase of over 30,000 persons, though the total number was 14,180 less than that reported in 1907. The average earnings were \$776 per head; there were few changes during the year in the rates of wages paid.

During 1908 and 1909 it hardly seems as if full allowance had been made for depreciation of plants. The form of the report, however, makes it difficult to give an exact opinion on this point, as part of the renewals are charged to working expenses and part to special funds, so that the total amount spent to make good the depreciation cannot be exactly ascertained. This, it may be said, is one of the weaker points of the report, otherwise a complete one. The appropriations for new property, necessarily suspended in 1908, as the smaller earnings of that year made it necessary either to omit them or to reduce the dividends, were renewed last year, a total of $15,000,000 being set aside for that purpose. The corporation has always recognized the necessity of adding to its works if its position in the industry is to be maintained; and since its organization it has spent the great sum of $495,212,000 for that purpose. Nearly one-third of its present property account is made up by these contributions.

The list of properties owned, as given in the report, is fairly complete so far as the manufacturing plants, the coal mines and the coke plants are concerned. As to iron ore the statement is limited to a brief list of developed mines in the Lake Superior region and in Alabama. In fact there is—as in previous reports—a noticeable reticence as to iron ores owned and controlled. Thus nothing is said with regard to the Great Northern leases and the results on that part of the Mesabi range last year. For the current year, also, nothing is said. There is, however, among the appropriations for 1910 one of $3,200,000 for "reserve fund to cover advanced mining royalties"; and this, or the greater part of it, is obviously intended to meet the minimum royalties and charges on those leases, which are not yet productive. The corporation seems to be paying rather a heavy price for this addition to its ore reserves; but from its point of view their control was essential to its plans.

The Iron and Steel Markets.

The general course of the markets during 1909 was a new vindication of the old law of supply and demand. The halting and hesitation manifest at the opening of the year disappeared as soon as the large producers abandoned their untenable position, gave up their policy of maintaining prices and permitted the market to take its course. From that time on business increased with almost unprecedented rapidity; and as a natural consequence of increasing demand prices crept up gradually until they reached almost the level from which they had dropped. These gradual advances came naturally as the result of improved demand and did not check or limit the volume of trade.

The tariff discussion in the summer did not seriously affect the market. As soon as it became apparent that final settlement rested with the Senate, the situation was generally discounted. The final outcome—a spectacular reduction in the duties on pig iron, steel rails and a few other items, and a practical maintenance of other rates—was generally anticipated, and had little effect on the market when the Payne-Aldrich bill finally became a law in August.

The rail question, which caused so much discussion in 1908, ended by a compromise which was generally accepted with little publicity. The rail mills quietly agreed to conform to the stricter specifications of the railroads, and maintained the price of $28 per ton. There was an increased demand for open-hearth rails.

Pittsburg. (By B. E. V. Luty.)—Seldom has a year in the iron trade exhibited such fluctutations in prices as occurred in 1909. The complete cycle was run, prices declining and then advancing. So much pomp and circumstance surrounded the maintenance of finished steel prices in 1908 after the panic of October, 1907, so violent was the break upon the abandonment of the price maintenance policy, and so quietly and gradually did prices steal upwards in the second half of the year that it requires a careful scrutiny of the opening and closing prices of the year to divest the mind of the impression that the net result of the year was a general and material lowering in the level of values.

As a matter of fact the absolute minimum price of merchant steel bars at the close of the year was $1 a ton higher than the nominal or official price at the opening, while plates and shapes showed an apparent reduction of $1 a ton. The nominal or official prices on bars, plates and shapes at the opening of the year were not generally observed, there having been shading on practically all important business, so that the net result of the year was an average advance in these three important products. Wire products suffered reductions of $8 per ton of 2000 lb. in plain wire, $7 in nails and $10 in barb wire, the subsequent advances amounting to $5 on each line, leaving an average net decline of about $3. Tinplates declined 25c. per box and recovered 20c.; black sheets made up all but $1 a ton of their loss, while galvanized sheets made up their entire loss. Standard steel rails suffered no fluctuation in the year.

Steel pipe alone of all finished steel products suffered a material net reduction. The reduction was five points or about $9.50 per ton of 2000 lbs., while the only advance was one point.

Unlike finished steel products, pig iron had found low points in 1908, the desultory attempts early in the year to maintain prices having been abandoned. An ill-advised marking up of prices in November and December, 1908, made the opening prices of 1909 higher than they should have been, considering the general situation, but even with such artificiality in the opening prices the closing prices of the year showed gains all along the line. Comparing the average quotations in December with those in January, gains were shown in pig iron, f.o.b. Valley furnaces, of $2.72 in bessemer, $1.50 in basic, $1.62 in foundry and $2 in gray forge.

At a conference of officials of the United States Steel Corporation with representatives of a few important independent producers on the afternoon of February 18, it was decided to abandon all concerted effort to maintain prices on finished steel products, with the single exception of standard rails. An exception was not made of rails without due deliberation; the abandonment of price maintenance was considered from the two standpoints of the ability or inability to hold prices, and the prospects of increased business at reductions. In the case of rails the number of producers was so small that the question of ability to maintain prices was relatively unimportant, and the decision rested upon the prospects of business. A hasty canvass of the railroads showed that no large business could be expected to follow a reduction; hence rails were excluded from the open market declaration.

The public utterances of officials of the United States Steel Corporation at the time of the break sought to convey the impression that it was brought about almost wholly by the cutting of some of the independents, but there is good reason to believe that this was the excuse rather than the reason. The Steel Corporation, however, was not wholly responsible for the taking of this oblique view. Several prominent independent interests had grown tired of the price maintenance game for a variety of reasons, but the one they selected to urge upon the Steel Corporation was that certain smaller independents were cutting into their trade.

The outcome of the price break was a general resumption of activity following more closely than even the most sanguine anticipated. The immediate effect of the open market declaration was to suspend shipments on the great bulk of contracts on books, pending a readjustment

AVERAGE PRICES AT PITTSBURG, 1909

Month.	Pig Iron.			Ferro-Mang.	Steel.					Nails.	
	Bessemer.	No. 2 Foundry.	Gray Forge.		Bessemer Billets.	Rails.	Black Sheets No. 28.	Tank Plate.	Steel Bars.	Wire per Keg.	Cut per Keg.
	$	$	$	$	$	$	c.	c.	c.	$	$
January	17.18	16.28	15.15	45.95	25.00	28.00	2.45	1.60	1.40	1.95	1.90
February	16.73	15.90	15.15	45.45	25.00	28.00	2.39	1.50	1.33	1.95	1.90
March	16.40	15.62	14.82	43.85	23.00	28.00	2.20	1.30	1.20	1.90	1.80
April	15.79	15.06	14.56	43.45	23.00	28.00	2.20	1.28	1.13	1.95	1.70
May	15.77	15.08	14.40	42.45	23 00	28.00	2.15	1.25	1.19	1.65	1.70
June	16.13	15.63	14.82	42.85	23.00	28.00	2.10	1.25	1.20	1.70	1.70
July	16.40	15.96	15.05	43.35	23.00	28.00	2.15	1.33	1.25	1.72	1.71
August	17.16	16.20	15.45	42.95	24.16	28.00	2.15	1.40	1.33	1.80	1.75
September	18.44	17.03	16.34	44.45	25.00	28.00	2.22	1.45	1.37	1.80	1.75
October	19.75	18.02	17.02	45.00	26.00	28.00	2.30	1.50	1.40	1.80	1.77
November	19.90	18.09	17.22	46.35	27.15	28.00	2.36	1.54	1.45	1.80	1.80
December	19.90	17.90	17.15	46.95	27.20	28.00	2.40	1.55	1.45	1.83	1.80
Year	17.46	16.40	15.59	44.42	24.58	28.00	2.26	1.41	1.31	1.82	1.77
Year 1908	17.23	16.28	15.28	46.38	26.25	28.00	2.50	1.64	1.48	1.99	1.83

of prices. In only a few particular instances did the mills attempt to hold customers to their contracts. Bar, plate and shape contracts were soon adjusted to a new level, although ultimately sales were made at a still lower level. The curve of pig-iron production, which trended continually upward from June, 1909, through February, 1909, dropped sharply in March and again in April, chiefly on account of the suspension of shipments on contracts.

If the resumption of activity was due to the break in prices the move was thoroughly efficacious; if it was not due to that cause, if the resumption was marked to come in any event, it constituted a serious arraignment of the judgment of those who held prices for 15 months, only to desert the cause when the fruit was ripe. The former assumption seems to be the true one.

Standard rails, as noted, commanded unchanged prices during the year. The $28 rail price was first made in the spring of 1901, as the United States Steel Corporation was being formed, and has not been changed since.

Plates and shapes had been 1.70c. in 1907; June 9, 1908, the official price was reduced to 1.60c. At times in 1908 there was extensive shading, down to 1.40c. or lower, and the 1.60c. official price was probably being better held at the opening of 1909 than were the respective prices of 1.70c. and 1.60c. during much of the preceding year. Following the open market declaration, plates and shapes dropped, February 19 and 20, to 1.30c., and existing contracts were largely adjusted to that basis. During parts of March and April they sold openly at 1.20c., but 1.10c. was done in special cases.

Steel bars had been 1.60c. in 1907, and were reduced to 1.40c. June 1, 1908, opening 1909 with that price fairly well held. The first break was to 1.20c., but in parts of March and April sales were freely made at 1.10c., and 1.05c. was done in special cases.

In the latter part of April, plates, shapes and bars firmed up, closing the month at 1.15c. for bars and 1.30c. for plates and shapes. Bars soon gained $1 a ton upon plates and shapes, and thereafter there was a steadily advancing market on the three products, closing the year with bars at 1.45c. and plates and shapes at 1.55c., with $1 a ton more asked in some cases, particularly on deliveries more than three months ahead.

Merchant steel pipe opened the year at a nominal price of 80 per cent. off list, which with the customary concession to large jobbers made the actual inside price 81 and 5. There had been a two-point reduction from the 1907 price on June 9, 1908. March 1 the National Tube Company promulgated new prices, carrying a reduction of five points, or about $9.50 per net ton. October 1, a one-point advance was made.

Sheets opened the year at 2.45c. for black and 3.50c. for galvanized, 28 gage. The first reduction was February 24, making black sheets 2.20c. and galvanized 3.25c. In the next four months these prices were cut, at times, to about 2.10c. and 3.15c. In July and August the market firmed up, closing August with 2.20c. on black and 3.25c. on galvanized sheets. September 28, an advance of $2 a ton was made, making black sheets 2.30c. and galvanized 3.35c. November 12, prices were advanced to 2.40c. for black and 3.50c. for galvanized, the spread between black and galvanized sheets being increased 5c. per 100 lb., which only partly made up for the advance in spelter.

Tinplates were reduced from $3.65 to $3.40 per box for 100 lb. cokes on March 15, and were advanced September 28 and November 12, 10c. each time, making the closing price $3.60 per box.

A peculiar condition confronted the wire trade when the open market declaration was made, as the jobbers had laid in large stocks for the spring trade. At first a general reduction appeared inevitable, but the threat of a large reduction served to hold the wavering producers fairly well in line. There was some cutting, particularly in April, but a general reduction was postponed until May 1, when jobbers had fairly well worked off their stocks and were ready to place additional orders. On that date prices were reduced from $1.95 per keg to $1.60 on wire nails, from 1.80c. to 1.40c. on plain wire, from 2.40c. to 1.90c. on galvanized barb wire and from 2.10c. to 1.60c. on painted barb wire, $7, $8 and $10 per net ton respectively. New business came with a rush, and May 15 prices were marked up $2 a ton. July 24 another $2 advance occurred, and December 12 $1 was added, leaving prices $2, $3 and $5 respectively below the opening.

The course of pig iron prices is shown in the accompanying table, which is made up from daily prices averaged each month. Prices at the opening of the year were inflated, as there had been a sharp advance in November and December of the preceding year, based upon insufficient grounds. Had it not been for this inflation the pig iron market might have passed through the period of readjustment in finished steel prices with but little decline. As it was, pig iron prices declined sharply, reaching a minimum early in May of about $14.50, Valley, for bessemer and $13.85@13.90, Valley, for No. 2 foundry and basic, Pittsburg prices being 90c. higher. Thereafter the market advanced steadily.

The most striking feature of the local market was the heavy buying of bessemer iron by independent steel works, the Republic Iron and Steel Company, Youngstown Sheet and Tube Company, Jones & Laughlin Steel Company, Cambria Steel Company and Lackawanna Steel

Company. In ordinary conditions these companies are practically self-sustaining in pig iron, but when under pressure they take outside iron. The five companies bought a total of more than 400,000 tons of bessemer iron, chiefly from Valley furnaces, the purchases beginning with 10,000 tons by the Republic May 20, at $14.50, Valley. The heaviest buying was in September and October.

Alabama. (L. W. Friedman.)—With the production at a top notch, the quotations firm around a high figure, a general reverse of conditions that existed at the beginning of the twelve months, the year 1909 at the close was a good one for the Alabama pig iron manufacturers, in the face of what was expected and dreaded. The authoritative figures give the State credit for 1,706,652 tons of pig iron during 1909, while the year went out with but little of this iron in the furnace yards belonging to the producers. The quotations were anything but high for the first part of the year, and the make was kept down. When change for the better came on and the demand improved better quotations followed. Pig iron that in 1907 (to September) brought above $24 and $25 per ton spot, was to be purchased during 1909 as low as $11 and even $10.65 per ton, No. 2 foundry, in Alabama; some brokers and speculators took advantage of this condition and purchased. The demand became very slack and the furnace companies curtailed the production, and in June the low water mark was reached in output, the Alabama total being 99,355 tons for the month.

Before the summer was over in Alabama the manufacturers saw prosperity ahead and attention was given to preparation for iron making. The quotations began taking on advances of 50c. and then $1 per ton.

The improving demand in the fall advanced quotations and $15 per ton, No. 2 foundry, was seen before the close of the year. While some of the furnaces sold in large quantities when the quotations were down at $11 per ton, the opinion evidently being that it would be better to sell and keep the furnaces in blast than to carry the iron or shut down, still there was some profit at these prices.

The figures of the output tell the story of the year's pig iron transactions in Alabama: January, 148,404 tons; February, 134,909; March, 144,873; April, 139,493; May, 113,524; June, 99,355; July, 104,775; August, 137,363; September, 151,803; October, 176,266; November, 182,185; December, 173,702; total, 1,706,652 tons.

Chicago. (E. Morrison.)—In its first half the year 1909 was disappointing in nearly all lines of the iron and steel trade, but the second half showed boom conditions for finished products and a much better sale of pig iron. Opening in depression, January saw hardly any buying of pig iron, a carload to 100 tons being the average melter's purchase for the immediate needs of his light business. Finished materials had hardly any sale, except railroad supplies. Foundries continued to need very little iron throughout February, and by March prices of both Northern and Southern had weakened to their lowest records for the year—$16.50 for Northern No. 2 and $15.35 for Southern No. 2 ($11 Birmingham).

The cut in prices of iron and steel products in February had the effect of stimulating sales of these products almost immediately, but the wave of increased buying did not reach the pig iron market until several months later. The greatest buyers of the year, the railroads, did not begin placing their very heavy orders until the latter part of April; early in that month the agricultural implement manufacturers, feeling sure of a prosperous year, placed heavy orders for bars and other materials, while the total tonnage of pig iron sales shot suddenly upward, with the feeling that the "bottom of the market" had been reached. It had been, and the spurt raised prices slightly on Southern, with the result that another period of inactivity for pig iron began. The average melter was not yet ready to buy liberally.

IRON AND STEEL PRICES AT CHICAGO.

Material.	1907		1908		1909	
	Highest.	Lowest.	Highest.	Lowest.	Highest.	Lowest.
Lake Superior Charcoal	$28.00	$25.00	$24.00	$19.50	$20.00	$19.50
Northern No. 2 Foundry	27.00	19.00	18.50	16.50	19.50	16.50
Southern No. 2 Foundry	27.35	19.35	17.85	15.35	19.85	15.35
Connellsville Coke	5.50	5.15	....	....	....	....
Bar Iron	1.865c	1.75c	1.65c	1.50c	1.60c.	1.30c.
Structural Material (a)	1.88c	1.865c	1.88c	1.78c	1.78c.	1.40c.

(a) Beams and channels, 3 in. to 15 in., and angles 3 in. to 6 in. x ½ in. or heavier.

The railroads, once started, came into the market rapidly for long-delayed purchases. By the middle of July rails, bars, plates and structural shapes were selling more heavily than at any period since 1907. Building projects of all kinds went forward in confidence; shops generally put on full forces of workmen and prices of iron and steel materials rose again. The purchase of about 55,000 tons of pig iron by the agricultural implement makers, in July, strengthened greatly both Northern and Southern pig iron and the strong condition for the rest of the year.

In the spring of 1909 the average sale of pig iron was of a small amount for early delivery. The summer saw active buying for the last half, and by August some melters were asking contracts to cover the first half of 1910. Furnace agents were reluctant to sell so far ahead at current prices, being confident of a rising market, and prices of both Northern and Southern iron naturally rose, with Northern furnaces well sold up for the rest of the year. Northern, by September, reached $18.50, and a month later it went to $19 minimum for No. 2, at which figure it stayed for the rest of the year. Southern's low quotations on No. 2 were $16.85 in July, $17.85 in August, $18.35 in September and $19.35 in October, remaining firm at the last named quotation until November, when some Southern iron was sold at 50c. less.

The months of November and December saw a quiet market for pig iron. Local furnaces were all in blast and Northern iron remained very firm. Little quick delivery iron was sold. Considerable business was done in December in resale Southern iron.

Lake Superior charcoal iron sold well throughout the year at uniform quotation of $19.50@20 per ton.

Seaboard Markets.—The course of the seaboard iron markets is determined chiefly by New York and Philadelphia. New York is the distributing point for a large territory in New York State and New England; Philadelphia not only has its own special territory, but is near to a large producing district in Eastern Pennsylvania, of which it is the chief outlet.

There are two distinct demands in the seaboard territory; the one being found in the direct consumers who buy for immediate use and the other in the manufacturers who buy raw iron and steel to make up into machinery and other finished forms. The seaboard territory is more a foundry than a steel-making region, and the market there is for foundry rather than steel-making pig, and for steel in finished forms. The exception to this is that the Philadelphia market takes a large quantity of steel billets and basic pig.

The seaboard markets followed the course of the general market rather closely. In almost all lines the year opened with dull trade and rather light buying. This continued until after the 1908 policy of maintaining prices was abandoned and an open market declared. From that time on business improved rapidly; there was sharp buying in all lines, while foundry and machine shop work increased in all quarters. Buying continued active, almost without intermission, until the latter part of November, when matters began to quiet down, and December was rather a slow month. This was taken, however, as rather an indication of the usual end-of-the-year lull, than as any threat of a coming depression.

Pig iron had been the only open market in 1908, and at the beginning of 1909 had reached rather low levels. These were emphasized in the early months of the year, and about the lowest points were reached in February and March. From that time on the quotations began to work up, until in December No. 2X foundry was quoted in Philadelphia at $19@19.50; forge at $18, and basic at $18.50@19. Southern iron sold well during the year, No. 2 Alabama foundry being for the most part about on a parity with Northern of the same grade. In November and December the market for Southern was disturbed by offerings of considerable quantities of speculative iron, which had been bought from furnaces earlier in the year, and held for an advance. Storage charges and interest forced out most of this iron, and it was sold at 50c. or 75c. below the price of $15, Birmingham, for No. 2 foundry which the furnaces were trying to maintain. For this reason chiefly Southern foundry closed the year at about 50c. per ton below the parity of Northern.

The only active market in finished material in 1908 had been structural steel. The open market did not so much affect this branch when it was declared in 1909, for the reason that much business had been done for months at quietly shaded prices. Structural business continued active throughout the year, and it is estimated that contracts calling for nearly 2,000,000 tons were placed in seaboard cities during the year. Other branches of the trade were active also after the break; bars, sheets, plates and wire all selling freely for consumption and manufacture. The sales of nails, bars and other material for building of the smaller class started up and rapidly developed into a very active trade. It was evident that large amounts of money were being put into small as well as large construction.

Railroad and terminal improvements and municipal work in and around New York, Philadelphia and Boston absorbed great quantities of material. Contracts for this work are generally made with the large mills directly, and do not appear on the local markets.

Range of Prices for Fifty Years.

The accompanying table, compiled from the records of the American Iron and Steel Association, gives the average yearly prices of a number of leading articles of iron and steel for a period of 50 years. The price of foundry iron given is at Philadelphia; of bessemer big at Pittsburg. Bar iron prices up to and including 1881 are at Philadelphia, the early manufacture of bars having been centered in eastern Pennsylvania and New Jersey. Other prices are at mill, or at central basing points. Iron rails ceased to be of commercial importance about 1880, steel rails supplanting them from that date. Wire nails first appeared on the market in commercial quantities about 1887; since that date they have been gradually supplanting cut nails, the latter now constituting not over 15 per cent. of the total production. In making comparisons, it must be remembered that from 1861 onward the prices were in currency which was depreciated in value from the gold standard. This depreciation reached its greatest point in 1864-65, and from that time on gradually decreased until it finally disappeared in 1879, with the full resumption of specie payments.

IRON AND STEEL PRICES FOR FIFTY YEARS.
(In tons of 2240 lb., except nails, which are in kegs of 100 lb.)

Year.	Pig Iron.		Bar Iron, Best.	Rails.		Nails.		Year.	Pig Iron.		Bar Iron, Best.	Rails.		Nails.	
	No. 1 F'dry.	Bes-semer.		Iron.	Steel.	Cut.	Wire.		No. 1 F'dry	Bes-semer.		Iron.	Steel.	Cut.	Wire.
	$	$	$	$	$	$	$		$	$	$	$	$	$	$
1860..	22.70	......	58.75	48.00	......	3.13	......	1885..	17.99	......	36.59	......	28.52	2.33	......
1861..	20.26	......	60.83	42.38	......	2.75	......	1886..	18.71	18.96	38.08	......	34.52	2.27	......
1862..	23.92	......	70.42	41.75	......	3.47	......	1887..	20.93	21.37	43.59	......	37.08	2.30	3.15
1863..	35.24	......	91.04	76.88	......	5.13	......	1888..	18.88	17.38	39.67	......	29.83	2.03	2.55
1864..	59.22	......	146.46	126.00	......	7.85	......	1889..	17.76	18.00	38.30	......	29.25	2.00	2.49
1865..	46.08	......	106.46	98.63	......	7.08	......	1890..	18.41	18.87	41.25	......	31.78	2.00	2.51
1866..	46.84	......	98.13	86.75	......	6.97	......	1891..	17.52	15.95	38.38	......	29.92	1.86	2.04
1867..	44.08	......	87.08	83.13	166.00	5.92	......	1892..	15.75	14.37	36.79	......	30.00	1.83	1.70
1868..	39.25	......	85.63	78.88	158.46	5.17	......	1893..	14.52	12.87	33.53	......	28.12	1.44	1.49
1869..	40.61	......	81.67	77.25	132.19	4.85	......	1894..	12.66	11.38	26.88	......	24.00	1.08	1.11
1870..	33.23	......	78.96	72.25	106.79	4.40	......	1895..	13.10	12.72	28.09	......	24.33	1.56	1.69
1871..	35.08	......	78.54	70.38	102.52	4.52	......	1896..	12.95	12.14	27.22	......	28.00	2.36	2.54
1872..	48.94	......	97.63	85.13	111.94	5.46	......	1897..	12.10	10.13	24.73	......	18.75	1.47	1.46
1873..	42.79	......	86.43	76.87	120.58	4.90	......	1898..	11.66	10.33	23.93	......	17.62	1.31	1.45
1874..	30.19	......	67.95	58.75	94.28	3.99	......	1899..	19.36	19.03	43.75	......	28.12	2.21	2.60
1875..	25.53	......	60.85	47.75	68.75	3.42	......	1900..	19.98	19.49	48.12	......	32.29	2.46	2.76
1876..	22.19	......	52.85	41.25	59.25	2.98	......	1901..	15.87	15.93	40.38	......	27.32	2.29	2.41
1877..	18.92	......	45.55	35.25	45.58	2.57	......	1902..	22.19	20.67	43.53	......	28.00	2.29	2.15
1878..	17.67	......	41.24	33.75	42.21	2.31	......	1903..	19.92	18.98	39.59	......	28.00	2.36	2.13
1879..	21.72	......	51.85	41.25	48.21	2.69	......	1904..	15.57	13.76	33.17	......	28.00	2.01	1.96
1880..	28.48	......	62.04	49.25	67.52	3.68	......	1905..	17.88	16.36	41.89	......	28.00	2.00	1.93
1881..	25.17	......	58.05	47.13	61.08	3.09	......	1906..	20.98	19.54	43.23	......	28.00	2.13	1.98
1882..	25.77	......	54.51	45.50	48.50	3.47	......	1907..	22.40	19.43	40.87	......	28.00	1.86	1.82
1883..	22.42	......	44.24	......	37.75	3.06	......	1908..	17.24	17.23	39.87	......	28.00	1.83	1.99
1884..	19.81	......	38.45	......	30.75	2.39	......	1909..	17.46	16.40	39.42	......	28.00	1.82	1.77

IRON AND STEEL PRODUCTION OF THE WORLD.

The total pig iron production of the world, as obtained from official returns from all the chief producing countries of the world and from the nearest possible estimates in others, dropped from 60,680,000 tons in 1907 to 48,640,500 in 1908; recovering in 1909 to 61,217,000 tons, an increase of 637,000 tons over 1907. In like manner the total steel production fell from 51,273,000 tons in 1907 to 44,359,200 in 1908, and recovered to 53,500,000 in 1909; the gain over 1907 being 2,227,000 tons, or considerably more than in pig iron. This disparity shows the increasing use of steel and its substitution for wrought iron in industry, which has been in progress for years past. The sharp changes noted in the three years were in large part due to the extreme fluctuations in the United States. Other countries showed a parallel course during the years noted, but in none of them were the changes nearly as great.

In 1909 the United States furnished 42.6 per cent. of the world's pig iron and 45.5 per cent. of the steel. Germany made 21.1 and 22.6 per cent., respectively; Great Britain, 16 and 11.2 per cent. These three large producers supplied 79.7 per cent. of the total pig iron and 79.3 per cent. of the steel. No other country approached any of these three in its output.

PIG IRON PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1900	1,311,949	1,161,180	87,612	2,714,298	7,549,665	23,990	2,296,191
1901	1,300,000	765,420	248,896	2,388,823	7,785,887	25,000	2,869,306
1902	1,335,000	1,102,910	325,076	2,427,427	8,402,660	24,500	2,597,435
1903	1,355,000	1,299,211	269,665	2,827,668	10,085,634	28,250	2,486,610
1904	1,369,500	1,307,399	274,777	2,999,787	10,103,941	27,600	2,978,325
1905	1,372,300	1,310,290	475,491	3,077,000	10,987,623	31,300	2,125,000
1906	1,403,500	1,431,160	550,618	3,319,032	12,478,067	30,450	2,350 000
1907	1,405,000	1,427,940	590,444	3,588,949	13,045,760	32,000	2,768,220
1908	1,650,000	1,206,440	572,123	3,391,150	11,813,511	112,924	2,748,000
1909	1,958,786	1,632,350	687,923	3,632,105	12,917,653	207,800	2,871,332

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1900	289,788	526,868	9,003,046	14,009,870	625,000	39,599,457
1901	294,118	528,375	7,977,459	16,132,408	635,000	40,950,692
1902	330,747	524,400	8,653,976	18,003,448	615,000	44,342,579
1903	380,284	506,825	8,952,183	18,297,400	625,000	47,113,730
1904	386,000	528,525	8,699,661	16,760,986	633,000	46,069,501
1905	383,100	531,200	9,746,221	23,340,258	655,000	54,054,783
1906	387,500	552,250	10,311,778	25,706,882	650,000	59,074,861
1907	385,000	603,100	10,082,638	26,193,863	556,900	60,680,014
1908	403,500	563,300	9,438,477	16,190,994	550,000	48,640,479
1909	389,000	443,000	9,818,916	26,108,199	550,000	61 217,064

STEEL PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1900	1,145,654	655,199	23,954	1,565,164	6,645,869	115,887	2,217,752
1901	1,142,500	526,670	26,501	1,425,351	6,394,222	121,300	2,230,000
1902	1,143,900	776,875	184,950	1,635,300	7,780,682	119,500	2,183,400
1903	1,146,000	981,740	181,514	1,854,620	8,801,515	116,000	2,410,938
1904	1,195,000	1,069,880	151,165	2,080,554	8,930,291	113,800	2,811,948
1905	1,188,000	1,023,500	403,449	2,210,284	10,066,553	117,300	1,650,000
1906	1,195,000	1,185,660	515,200	2,371 377	11,135,085	109,000	1,763,000
1907	1,195,500	1,183,500	516,300	2,677,805	12,063,632	115,000	2,076,000
1908	2,025,182	1,065,500	598,183	2,727,717	10,480,349	537,000	2,341,000
1909	1,969 538	1,370,000	766,795	3,034,571	12,049,834	661,600	2,471,000

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1900	144,355	300,536	5,130,800	10,382,069	400,000	28,727,239
1901	122,954	269,897	5,096,301	13,689,173	405,000	31,449,869
1902	163,564	283,500	5,102,420	15,186,406	412,000	34,972,497
1903	199,642	317,107	5,114,647	14,756,691	418,000	36,298,414
1904	193,759	333,522	5,107,309	13,746,051	415,000	36,148,079
1905	237,864	340,000	5,983,691	20,354,291	426,000	43,900,648
1906	251,600	351,900	6,565,670	23,772,506	420,000	49,635,998
1907	247,100	443,000	6,627,112	23,733,391	405,000	51,273,340
1908	239,500	427,100	5,380,372	14,247,619	300,000	44,359,522
1909	227,000	310,600	5,975,734	24,338,302	325,000	53,499,974

Iron and Steel in Foreign Countries.

As already noted, fluctuations in the production of foreign countries were much less marked than in the United States; but nearly all of them showed some recovery in 1909 from the depression which was world-wide in 1908.

Australia.—Efforts are being made to establish an iron industry in Australia by the offer of bounties for pig iron and other iron products. There are deposits of iron ore in New South Wales and Queensland, but hitherto the demand in Australia has been supplied chiefly by imports.

Austria-Hungary.—The full statistics of wrought iron and steel production in Austria, including Hungary and Bosnia, for 1909 are given in the accompanying table, in metric tons. The production includes a small quantity of iron blooms made in charcoal forges directly from the ore. Electric steel was made for the first time in 1908, when 4333 tons were made; in 1909 this increased to 9048 tons.

STEEL PRODUCTION OF AUSTRIA-HUNGARY.
(In metric tons.)

Steel.	Austria.	Hungary.	Bosnia.
Acid converter	694	44,283	....
Basic converter	236,487	961	....
Open-hearth	1,064,220	561,657	29,334
Puddled	6,600	171	....
Crucible	14,680	1,403	....
Electric	9,048	....	....
Total steel	1,331,729	608,475	29,334
Puddled (wrought) iron	72,765	22,428	....
Charcoal forge blooms	768	....	....
Total	1,405,262	630,903	29,334
Total, 1908	1,513,511	637,364	34,982

Belgium.—The iron industry in Belgium was much more active than in 1908; and foreign trade, upon which the country largely depends, was good. Belgium imports a considerable quantity of pig iron which is worked into finished products in its mills.

FOREIGN TRADE OF BELGIUM.
(In metric tons.)

	Imports.				Exports.			
	1906	1907	1908	1909	1906	1907	1908	1909
Pig iron	694,530	....	481,124	477,311	31,445	....	119,095	19,362
Wrought iron	83,643	....	270,273	360,255	530,119	....	941,374	177,693
Steel	259,077	....			245,101	....		
Total	1,037,250	957,286	751,397	837,566	807,665	1,128,287	1,060,469	1,197,055

PIG IRON PRODUCTION IN BELGIUM.
(In metric tons.)

	1903	1904	1905	1906	1907	1908	1909.
Foundry iron	....	99,350	98,170	101,430	100,020	76,190	89,960
Forge iron	....	224,410	206,309	226,900	226,430	127,630	156,590
Steel pig	....	963,840	1,006,641	1,103,130	1,101,490	1,002,620	1,386,800
Total	1,216,500	1,287,400	1,311,120	1,431,460	1,427,940	1,206,440	1,632,350

Canada.—The iron industry of Canada was for the most part prosperous, as shown by the increase in production in the tables.

The year 1909 was marked by two important consolidations. The long controversy between the Dominion Steel and the Dominion Coal companies was ended by the consolidation of the two. A merger was arranged embracing several iron and steel companies, principally in western Ontario, and a charter applied for for the Canadian Steel Corporation, capital $25,000,000, with headquarters at Hamilton, Ont. The companies included are the Hamilton Steel and Iron Company, Canada Screw Company, of Hamilton, Nut and Bolt Company, Toronto, with branches at Branford and Gananoque, and the Montreal Rolling Mills Company. The Algoma Company secured additional capital from England, and is planning important extensions in its works at Sault Ste. Marie and its iron mines on the Michipicoten range.

PIG IRON PRODUCTION IN CANADA.
(In tons of 2240 lb.)

	1902	1903	1904	1905	1906	1907	1908	1909
Foundry and forge	....	....	....	146,698	130,120	84,979	114,951	149,580
Bessemer	....	....	....	149,203	165,609	154,910	112,811	169,545
Basic	....	....	....	172,102	246,228	341,257	335,410	357,965
Total	319,557	265,418	270,942	468,003	541,957	581,146	563,172	677,090

STEEL PRODUCTION IN CANADA. (a)

	1908				1909			
	Converter.	Open-Hearth.	Special.	Total.	Converter.	Open-Hearth.	Special.	Total.
Ingots	135,557	443,442	713	579,712	204,718	534,985	....	739,703
Castings	....	9,051	....	9,051	....	15,016	....	15,016
Total	135,557	452,493	713	588,763	204,718	550,001	....	754,719

(a) Reported by Statistical Section, Mines Department.

China.—The important iron works at Hanyang have been described in the *Engineering and Mining Journal* of June 11, 1910. A contract to export iron ore and pig iron to the United States is noted elsewhere.

France.—There were no important changes in France, but a general improvement was manifest in production and trade.

The steel ingots made in 1909 are classified as follows: Acid converter, 76,981; basic converter, 1,853,327; open-hearth, chiefly basic, 1,080,912; crucible, 16,895; electric, 6456 metric tons. All classes of steel showed an increase last year except acid converter. The raw material used in making this steel in 1909 included 2,485,425 tons pig iron, of which 142,903 tons were classed as bessemer pig, 2,111,095 as basic pig and 231,427 as other iron; 127,196 tons ferro-manganese and other alloys; 810,778 tons scrap and 17,887 tons ore.

PIG IRON PRODUCTION IN FRANCE.
(In metric tons.)

	1902	1903	1904	1905	1906	1907	1908	1909
Foundry	....	....	....	635,672	591,275	651,700	695,527	749,247
Forge	....	....	....	705,691	741,571	673,885	543,067	538,053
Bessemer	....	....	....	160,411	149 971	122,046	118,121	118,002
Basic	....	....	....	1,530,671	1,784,726	1,988,343	1,949,107	2,172,718
Special irons	....	....	....	44,267	51,489	152,975	85,328	54,085
Total	2,427,427	2,827,668	2,999,787	3,076,712	3,319,032	3,588,949	3,391,150	3,632,105

IRON AND STEEL PRODUCTION IN FRANCE.
(In metric tons.)

	1902	1903	1904	1905	1906	1907	1908	1909
Wrought iron	625,826	595,831	554,632	669,841	747,900	687,249	563,745	519,200
Steel ingots	1,635,300	1,854,620	2,080,554	2,210,284	2,436,322	2,766,773	2,727,617	3,034,571
Finished steel	1,231,652	1,317,400	1,482,708	1,442,071	1,454,456	2,261,217	1,894,022	2,043,022

Germany.—The iron trade in Germany was generally prosperous, so far as production was concerned. The export trade was good. There was some complaint of low quotations, especially as to prices made by the steel syndicate for the purpose of securing foreign orders.

Steel is the main production of Germany. Of the total given in the table for 1909 there was 63.7 per cent. in 1909 made in the converter;

PRODUCTION OF PIG IRON IN GERMANY.
(In metric tons.)

	1903	1904	1905	1906	1907	1908	1909
Foundry iron	1,798,773	1,865,599	1,905,668	2,108,684	2,259,416	2,254,644	2,491,919
Forge iron	859,253	819,239	827,498	854,536	786,113	635,228	652,306
Steel pig	703,130	636,350	714,335	943,573	1,034,650	934,940	1,099,779
Bessemer pig	446,701	392,706	425,237	482,740	471,355	361,472	412,118
Thomas pig	6,277,777	6,390,047	7,114,885	8,088,534	8,494,226	7,627,227	8,261,538
Total	10,085,634	10,103,941	10,987,623	12,478,067	13,045,760	11,813,511	12,917,653

37.5 per cent. in the open-hearth furnace; and 0.8 per cent. by other methods. Direct castings, amounting to 192,883 tons in 1908 and 206,486 tons in 1909, are included in the figures. In 1909 there were 17 works making acid steel, 87 making basic steel, 24 crucible steel, and 8 electric steel. There were 30 works using converters and 74 using open-hearth furnaces.

PRODUCTION OF STEEL IN GERMANY.
(In metric tons.)

	1906		1907		1908		1909	
	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.
Converter ingots...	407,688	6,945,526	387,120	7,212,454	374,100	6,510,754	151,148	7,517,451
Open-hearth ingots	230,668	3,534,612	212,620	4,039,940	224,211	3,969,595	311,812	3 967,581
Special steels......	77,596	111,717	85,421	126,077	107,719	....	101,842	....
Total (*a*)...	715,952	10,591,855	685,161	11,378,471	706,030	10,480,349	564,802	11,485,032

(*a*) Includes direct castings.

GERMAN IMPORTS AND EXPORTS OF IRON ORE.
(In metric tons.)

	1905	1906	1907	1908	1909
Imports.......	6,085,196	6,730,636	8,476,076	7,732,729	8,366,599
Exports.......	3,698,563	3,212,977	3,904,400	3,067,870	2,825,007

GROWTH OF CONSUMPTION OF IRON IN GERMANY.
(In metric tons.)

	1880	1890	1900	1907	1908	1909.
Pig iron production...............	2,729,038	4,658,451	8,520,541	13,045,760	11,813,511	12,917,653
Imported as pig..................	238,572	405,627	827,095	607,729	399,661	318,938
Imported as steel, etc. (*a*).........	86,524	190,892	338,980	459,060	344,583	479,513
Total supply.................	3,054,134	5,254,970	9,886,616	14,112,549	12,557,755	13,716,114
Exported as pig..................	318,879	181,850	190,505	385,766	421,611	644,935
Exported as steel, etc. (*a*).........	982,721	1,152,169	2,118,772	4,706,587	4,930,399	5,032,653
Total exports................	1,301,600	1,334,019	2,309,277	5,092,353	5,352,010	5,677,588
Consumption.................	1,752,534	3,920,951	7,377.339	9,020,196	7,205,745	8,038,526
Consumption per head, kg.........	25.2	81.7	131.1	145.1	114.4	125.8

(*a*) Reduced to terms of pig iron at the rate of 1 ton steel=1.33 tons pig iron.

The total increase in 1909 over 1908 was 863,455 tons, or 7.8 per cent. The gain was wholly in basic converter steel, the make of which increased 1,006,697 tons, or 15.5 per cent. Acid open-hearth steel increased 87,601 tons, or 39.1 per cent., while acid converter steel decreased 222,952 tons, or 59.6 per cent. The other classes of steel showed small losses. The basic converter remains the great steel maker of Germany.

GERMAN EXPORTS AND IMPORTS OF IRON AND STEEL.
(In metric tons.)

	1905	1906	1907	1908	1909
Exports.......	3,349,968	3,619,796	3,432,707	3,731,289	4,044,391
Imports.......	322,907	690,081	813,104	559,530	458,541

Russia.—Production showed some improvement in 1909, and the industrial conditions were generally better. The government is planning extensive railroad work, and some is already in progress on the Siberian railway.

PRODUCTION OF IRON AND STEEL IN RUSSIA.
(In metric tons.)

	1902	1903	1904	1905	1906	1907	1908 (a)	1909
Iron ore...............	3,987,303	4,218,600	5,272,300	4,050,000	4,580,000	4,400,000	4,450,000	4,750,000
Pig iron...............	2,597,435	2,486,610	2,978,325	2,125,000	2,350,000	2,768,220	2,748,000	2,871,332
Steel ingots............	2,183,400	2,410,938	2,811,948	1,650,000	1,763,000	2,076,000	2,341,000	2,477,000

(a) Estimated.

Spain.—There was little change in the iron industries in 1909. There was, however, a considerable gain in the exports of iron ore.

PRODUCTION OF IRON AND STEEL IN SPAIN.
(In metric tons.)

	1902	1903	1904	1905	1906 (a)	1907 (a)	1908 (a)	1909 (a)
Pig iron................	330,747	380,284	386,000	383,100	387,500	385,000	375,000	403,000
Wrought iron...........	53,252	53,288	53,177	52,250	57,100	53,200	51,000	49,500
Bessemer steel..........	103,389	105,263	93,100	113,664	116,200	115,500	111,500	113,250
Open-hearth steel.......	60,175	94,379	100,659	124,200	135,400	131,600	128,000	131,750
Total steel...........	163,564	199,642	193,759	237,864	251,600	247,100	239,500	245 000

(a) Estimated.

Sweden.—The iron industry was seriously affected by the general strike of workmen in the latter part of 1909; and this accounts for the large decreases in production and exports.

SWEDISH PRODUCTION AND EXPORTS.
(In metric tons.)

	1907			1908			1909		
	Pig Iron.	Wrought Iron.	Steel.	Pig Iron.	Wrought Iron.	Steel.	Pig Iron.	Wrought Iron.	Steel.
Production	603,100	177,100	(a) 443,000	563,300	148,500	(b)427,100	443,000	116,900	(c)310,600
Exports.........	146,000	44,100	209,100	116,000	26,000	170,500	105,700	21,000	189,500

(a) Includes 82,000 tons bessemer and 361,000 tons open-hearth steel. (b) Includes 79,500 tons bessemer and 347,600 open-hearth. (c) Includes 63,400 tons bessemer and 247,200 open-hearth.

United Kingdom.—The total production of pig-iron in 1909 was 9,664,287 tons, which compares with 9,289,840 tons in 1908, 9,923,856 tons in 1907, 10,149,388 tons in 1906, and 9,592,737 tons in 1905. In 1909 the output was 374,447 tons more than in 1908, though still less by 259,569 tons than in 1907, and by 485,101 tons than the record production of 1906. The production of forge and foundry pig remained at about the same figure during the two years. The production of basic increased by some 230,000 tons in 1909. The bessemer output also increased by 183,000 tons.

Steel production, like pig iron, showed a considerable gain over 1908, but was less than in 1907 or 1906. The make of wrought or puddled iron was about the same in 1909 as in the preceding year.

PRODUCTION OF STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

	1903	1904	1905	1906	1907	1908	1909
Open-hearth	3,124,083	3,245,346	3,879,748	4,554,936	4,663,489	3,817,103	4,148,408
Bessemer	910,018	1,781,533	2,009,712	1,907,338	1,859,259	1,478,539	1,733,220
Total	5,034,101	5,026,879	5,889,460	6,462,274	6,522,748	5,295,642	5,881,628

ACID AND BASIC STEEL IN THE UNITED KINGDOM.
(In tons of 2240 lb.)

	1907			1908			1909		
	Acid.	Basic.	Total.	Acid.	Basic.	Total.	Acid.	Basic.	Total.
Open-hearth	3,384,780	1,278,709	4,663,489	2,578,840	1,238,263	3,817,103	2,763,158	1,385,250	4,148,408
Converter	1,280,315	578,944	1,859,259	906,466	572,073	1,478,539	1,111,042	622,178	1,733,220
Total	4,665,095	1,857,653	6,522,748	3,485,306	1,810,336	5,295,642	3,874,200	2,007,428	5,881,628

Great Britain is a large exporter of iron and steel. The total value of its exports, however, was less by £6,242,985 in 1909 than in the preceding year. The loss was largely due to German and Belgian competition.

EXPORTS, UNITED KINGDOM.
(In tons of 2240 lb.)

	1903	1904	1905	1906	1907	1908	1909
Pig iron	1,065,380	810,934	981,891	1,662,820	1,947,925	1,295,767	1,136,369
Wrought iron	203,619	170,505	183,406	200,182	211,771	172,072	170,189
Sheets	......	385,408	407,021	442,414	469,329	390,281	494,826
Plates	161,722	152,337	204,503	275,045	300,590	207,278	167,797
Rails	604,076	525,371	546,644	460,328	433,638	435,739	571,524
Steel shapes, etc	156,821	122,930	151,809	226,230	338,716	275,022	305 530
Tin plates	292,800	359,634	354,951	374,802	405,329	403,007	439,804
All other kinds	......	735,723	891,290	1,040,379	1,059,068	921,810	932,024

EXPORTS AND IMPORTS OF UNITED KINGDOM.
(Values.)

	1903	1904	1905	1906	1907	1908	1909
Exports..........	£54,741,296	£53,587,013	£60,524,755	£75,256,655	£88,448,689	£78,914,315	£72,271,330
Imports..........	8,662,481	12,529,212	13,128,270	13,486,724	12,527,157	12,236,417	12,409,781

Some Notes on Iron Ore Production.

Georgia. (S. W. McCallie.)—During the early part of 1909, iron-ore mining was almost at a standstill, but the industry greatly improved in the last months of the year, both in the fossil and in the brown iron-ore districts. One of the most important developments in the former districts was the opening of mines by the Pigeon Mountain Iron Company, near Lafayette, Walker county. Another important development which will likely add greatly to the ore output in the Cartersville district is the reopening of the Wheeler and the Allatoona ore banks, near Emerson, by the Lafayette Mining, Coal and Railroad Company.

Work in the Lake Superior Region. (Dwight E. Woodbridge.)—A notable occurrence in this region in 1909 was the beginning of shipments from the Cuyuna range in Minnesota. The first shipment was made over the Sault line to the port of Ashland. This shipment is a notable occurrence, marking the advent of a new district, the possibilities of which are great.

Another eventful occurrence of the year was the beginning of shipments from a new mine on the Vermillion, the first of its kind opened since 1888. Many millions had been expended in fruitless exploration there, and the Section 30 property is the only one that, to date, is a mine. About 50,000 tons of exceedingly high-grade bessemer hematite will be sent forword. It is understood that part of this ore was sold, Lake Erie ports, at better than $7 per ton, or $2 above the average price for bessemer ores.

The year witnessed remarkable exploratory activity on this range, and great activity on two more. The success of one exploration on the Vermillion stimulated many speculative companies on that range, and a large amount of deep drilling was in progress, two old shafts pumped out and one or two working shafts were sunk. No workable iron orebodies have yet been discovered. Drilling and testpitting were in progress at various places. With the advance of knowledge as to the Vermillion it is reasonable to expect favorable results from some of this work.

The second district of remarkable exploration activity is on the new Cuyuna, where probably 50 drills are at work and where some excellent ore is known to be found. Those who were skeptical of this district have been proved in the wrong. It is an iron district and is showing a few holes of as high-grade ore as one could ask for. It will be a valuable addition to the available iron-ore tonnage of Minnesota and may be a very large addition.

For two or three years exploration on the Menominee has been fruitful in results. Old mines are being enlarged, new ones are being found, and the end is not yet. The same is true of the Marquette; a shipper since 1855, it is today a greater district than ever before, and its future looks most promising. In the Negaunee and Princeton sections the recent finds have been really magnificent.

So far as the development of new mines is concerned, the Mesabi range leads. It must, in order to maintain a production equivalent to 68 per cent. of the Lake region, as it is scheduled for this year. The Hill Ore Lands, so called, will come in for a production in 1910. It is probably no secret that these lands have proved somewhat disappointing to the Steel Corporation, both as to tonnage and grade developed. Still, they contain much ore. The year 1910 will see the beginning of concentration of sandy ores of the Trout lake section by the Oliver company, as the first sections of its 10,000-ton concentrating works are nearly ready.

The drift toward steam shoveling ore continued. It was accentuated by the beginning of work on a mass of overburden at Hibbing, that lies 120 ft. thick. It is probable that the time will soon come when mine managers will no longer attempt to build long and costly approaches to their deeper shovel pits on grades economical for locomotives, but will adopt stationary hoisting plants of capacity to pull loaded 50-ton standard-gage cars out of their mines. The economy of this innovation ought to be apparent.

New Jersey. (By H. B. Kümmel.)—During 1909 the iron mining industry in New Jersey recovered largely from the general depression and stagnation which prevailed during the preceding year. Fewer mines were reported active, but the production at those which were worked was in most cases considerably in excess of that for 1908. The following mines are reported as having been active during all or a portion of the years: Ahles, Shoemaker, Washington, Mount Hope group, Richard, Hude, Hurd (at Wharton), Hoff, Wharton, Orchard and Peters. With the exception of the Ahles mine the product of which is a soft, manganiferous ore, and a lesser amount of limonite from the Shoemaker, all the ore mined was magnetite, the total production being 539,779 long tons. This is an increase of 107,213 tons over that of 1908, but is less than the maximum of 558,137 tons in 1907. The reports show that at the close of the year 101,478 tons remained on the dumps, which is 13,740 tons less than at the close of 1908, so that the consumption was somewhat in excess of the amount mined.

The amount of metallic iron in the ore varied considerably, the lowest reported being a few thousand tons of 45-per cent. ore, while the best was about 100,000 tons carrying 59 per cent. The average metallic iron in all the ore mined was reported to be 56.06 per cent.

Any endeavor to obtain the actual gross commercial value of the ore at the mines at attended with difficulty. About 90 per cent. or more of the ore mined was sent to furnaces controlled by the companies which own the mines and was not sold in the market. Under these conditions the value of the ore at the mine is largely a matter of bookkeeping, each company having its own practice as to the value at which the ore is charged. The highest figures reported were $4 per ton, the lowest $2.75. In each case the ore contained upwards of 58 per cent. metallic iron. The reported value is $1,690,496, an increase of $433,418 over that of 1908. The average value per ton was $3.13 as against $2.94 in 1908, an increase of 19c. per ton. This value is slightly less than the actual selling price of some of the ore having nearly the average content of metallic iron, so that $1,690,494 is probably a little under rather than over the true commercial value of the ore.

With increasing depth and extent of underground workings the mines become more expensive to operate through greater cost for pumping, hauling, hoisting, etc. This tendency has been met in many mines by more efficient machinery and more economical methods, so that mining costs in the best-equipped mines are today probably not greater than they were 20 or 30 years ago, although the mines are much deeper. Whether the maximum of efficiency and economical working has yet been attained, or whether as greater depths are reached increased costs from this cause can be met by further economy, has yet to be demonstrated. Many mines in the State have been abandoned for the time being, at least, because under present conditions they could not be profitably worked. Owing to varying conditions, it is hardly possible to compare working costs in two mines, or to give figures which are of more than general application, but the following percentages based on the actual experience of one company in 1909 are in general indicative of the mining costs in well-equipped and well-managed New Jersey magnetic mines:

Labor at mines, 63.8 per cent. of total; superintendents and other overhead charges, 1.6; coal, including freight on the same, 17.9; timber, including freight, 2.1; powder, fuse, oils, candles and all other supplies 13.5; incidental expenses, taxes, accidents, etc., 1.1 per cent. The total iron ore mined since 1870 in New Jersey has been reported at 18,458,287 long tons.

New Mexico. (By R. V. Smith.)—Up to the end of 1909 the Colorado Fuel and Iron Company had extracted over 1,000,000 tons of iron ore with open-cut and milling methods at Hanover and Fierro, in Grant county, since the mines were opened in 1900. During 1909 new surface arrangements were installed at Fierro, and the ores are now being blocked out to a lower level. The output from Fierro was nearly 500 tons per day for most of 1909, giving a total production of about 124,000 tons. The company worked a force of about 40 men at Elder, on the El Paso & Southwestern railroad, 35 miles above Carrizozo, taking out ore for shipment in 1910. The deposits of the Oscura mountains may be opened in 1910 by Duluth capitalists whose intentions are to build from White Oaks to the Oscuras and erect an iron-reduction plant at or near the White Oaks coalfields.

New York. (By D. H. Newland.)—The record of the iron mining industry in 1909 reflected the course of the market—continued depression during the early months and a quick upturn later which finally broke the spell of the 1907 panic. Before the close of the year the mines had resumed operations at nearly the old rate. Their output consequently was larger than that in 1908, the actual increase amounting to nearly 200,000 tons; the total was about 900,000 tons. Two new properties were brought to the producing stage; these were the magnetite mines of the Salisbury Steel and Iron Company in Herkimer county and the mines of the Ontario Iron Ore Company on the Clinton hematite belt in Wayne county. Many of the companies took advantage of the lull in business to extend their development work and improve their installations. The new shaft of the Port Henry Iron Company and the extensive additions to the plant of Witherbee, Sherman & Co., will probably bring Mineville to a new record in 1910. Exploration of the titaniferous magnetites at Lake Sanford was actively prosecuted by the McIntyre Iron Company, but shipments must wait the construction of a railroad, to the immediate undertaking of which the State forestry laws are an obstacle. Prominent metallurgists have expressed confidence in the feasibility of using this ore, at least when mixed with ordinary grades, in the blast furnace. The reopening of some of the old limonite mines in Dutchess county was under consideration during the year.

The Treatment of Steel in Electric Furnaces.[1]

By Henry M. Howe.

In an admirable article in the *Revue de Métallurgie*,[2] C. Clausel de Coussergues describes and discusses at great length and in a most interesting way the treatment of steel in electric furnaces. In taking his paper as a peg whereon to hang a sermon my purpose is not so much to compare the various electric furnaces as to consider with him the bearing of the phenomena noted in these furnaces on our general ideas about the purification of iron, i.e., the removal of carbon, phosphorus and sulphur, whether in the bessemer converter or the open hearth or electric furnace. In beginning, it may be well to point out that the processes carried out in these electric furnaces are not really electric processes. Electricity is used in them solely as a source of heat, and the purification is brought about by the same old means to the use of which in the puddling, bessemer, open-hearth, and blast-furnace processes we have so long been accustomed. That is to say, carbon, silicon and phosphorus are removed chiefly by oxidizing them to carbonic oxide, silica, and phosphoric acid, by means of iron oxide either formed in the process itself with atmospheric oxygen, as in both the bessemer and open-hearth processes, or added in the form of iron ore as in the open-hearth and puddling processes. The sulphur is removed in part as sulphide of manganese, which distributes itself between metal and slag, quite as in the puddling, basic bessemer, and basic open-hearth processes, and partly as sulphide of calcium which passes apparently wholly into the slag, quite as in the blast furnace.

But though electricity is here used solely as a source of heat, it has the great advantage over other sources of heat that it can supply its heat without simultaneously introducing oxygen. In the bessemer process the blast which generates the heat acts essentially through introducing vast quantities of oxygen. The flame which supplies the heat to the puddling and open-hearth processes brings with it much oxygen, and even when it is called reducing it is in fact violently oxidizing to iron and most of the nonferrous elements which it contains. In the last analysis this freedom from oxygen seems to be the chief, if not the only, thing that gives the electric furnaces their advantage over others, as we shall see later.

The obstacle to the wide use of electric furnaces in iron metallurgy is the great cost of the electricity itself. It is true that these furnaces do their work of heating and melting much more cheaply than the crucible

[1] Reprint of an article published in *Eng. and Min. Journ.*, Aug. 28, 1909.
[2] 1909, VI, 589

furnace does, but still they do it much less cheaply than the blast furnace, the cupola furnace, the bessemer converter, or the open-hearth furnace, and this will be the case in general until the exhaustion of our coalfields shall have greatly increased the cost of coal. In cases where power is to be had at a small cost, for instance, near the coke ovens of great metallurgical works, it may, indeed, be possible to heat and melt with electricity more cheaply than with coal; but even in these cases it will probably be more profitable to use the power as a basis for some other industry, and to continue to use the blast furnace, cupola, converter, and open-hearth furnace for decades if not for generations to come.

That so costly a thing as electricity should compete with so cheap and efficient a thing as the iron blast furnace for the smelting of iron ores seems hardly to be on the cards. It might have been possible 50 years ago, before coke could be carried so cheaply to almost every place where it is needed; but it is hard to think of conditions such as to make it cheaper today to use current than coke. In places so remote and inaccessible that coke cannot be brought to them, one fears that this very inaccessibility and costliness of inward freight must imply such corresponding costliness of outward freight that the iron smelted from ore by means of electricity cannot be exported with profit.

Thus the natural work of the electric furnace is to replace the crucible furnace and to supplement the work of the converter and open-hearth furnace.

What the Electric Furnaces Are.—Electric furnaces may be regarded as large internally heated crucibles, or, if I may use the hibernianism, as closed open-hearth furnaces with the flame replaced either by means of electric arcs from carbon electrodes; or by means of a current of electricity which heats the bath by resistance, quite as in the case of common incandescent electric lights; or by both means. The treatment in these furnaces may consist of three distinct steps: (1) melting down; (2) oxidizing the phosphorus of the molten metal, and its carbon and silicon if any excess of these elements is present, by means of iron oxide; and (3) removal of suspended slag, etc., and deoxidizing and desulphurizing by deoxidizing agents, such as carbon, ferro-silicon, aluminum, and, most effective of all, by forming calcium sulphide in the furnace itself. Of these three steps, the third is the only one which seems appropriate to the electric furnace, because the first and second can, in general, be carried out more cheaply by other means.

Arc Furnaces.—In the arc furnaces the current may either pass both inward and outward through carbon electrodes which pass through the roof, or through the walls above the bath, as in the Stassano and Heroult furnaces (Figs. 1 and 2); or it may enter through such overhead electrodes and pass out through the bottom of the furnace, using the bath of metal as the lower electrode. Our natural fear is that this must endanger the bottom of the furnace, but abundant experience with the Giffre and Girod furnaces (Figs. 3 and 4) shows that this danger need not be serious. In the melting-down stage these overhead electrode fur-

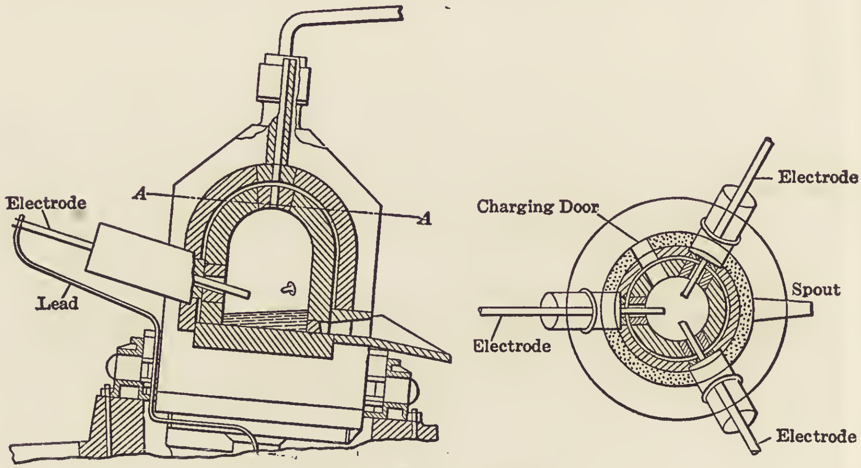


FIG. 1. STASSANO FURNACE.
Elevation and Transverse Section at A–A.

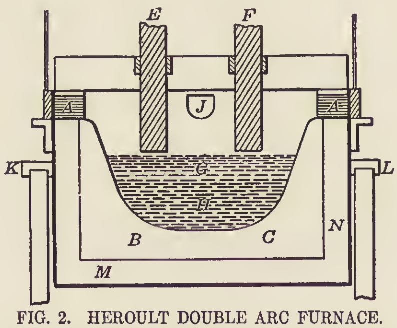


FIG. 2. HEROULT DOUBLE ARC FURNACE.
A A, working doors. *B C*, magnesite bottom. *E*, entering electrode. *F*, exit electrode.
G J, pouring spout. *K L*, trunnions. *M N*, outer brickwork.

naces (Stassano and Heroult) have the defect, which may be of moment, of having violent fluctuations of current, owing to the short-circuiting, the abrupt making and breaking of the arc, caused by the settling of the charge. From this defect the bottom-electrode furnaces (Giffre and Girod) are nearly free. This defect might be important in case the current used for the electric furnace formed a large fraction of the whole, because of the consequent abrupt fluctuations in the load on the generating machinery, unless it is practicable to build this machinery so that such fluctuations will not injure it.

Even in the arc furnaces an important part of the heat is generated by the resistance of the metal itself or of the slag, or of both, to the passage of the current. This seems to me to be true even of the Stassano furnace. It is true that other writers describe this furnace as heated solely by means of the arc, but, according to my own observations, the arc itself, though it nominally passes wholly above the charge, actually short circuits in no inconsiderable part through the charge, especially

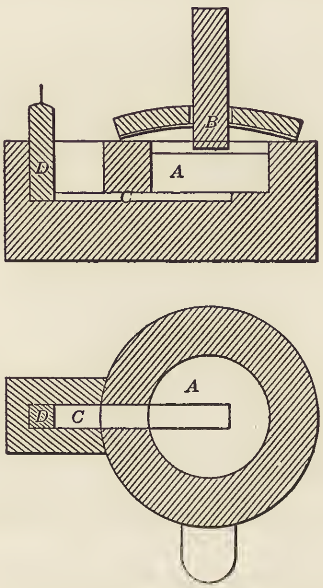


FIG. 3. GIFFRE FURNACE.
A, molten steel. *B*, upper electrode. *C*, solid steel connecting with lower electrode. *D*, lower electrode.

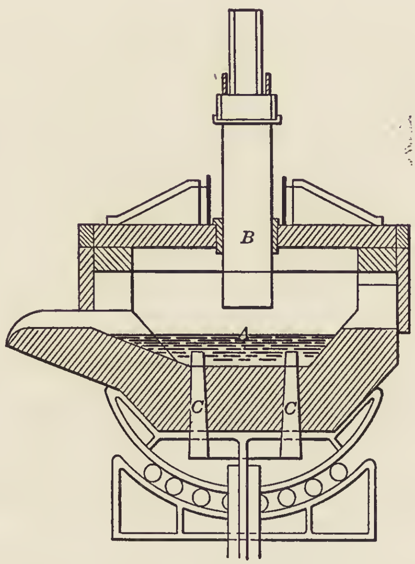


FIG. 4. GIROD FURNACE.
A, molten metal. *B*, upper electrode. *C*, lower electrode

during the melting down, with abrupt and wide variations in the current like those which occur in the Heroult furnace.

Induction Furnaces.—In those resistance furnaces which have come into the widest use (the Kjellin and the Roechling-Rodenhauser, Figs. 5 and 6), the current which does the heating is induced in the molten metal from without, somewhat as a current of great volume, but low e.m.f. is generated from the currents of high e.m.f., by means of which the electricity is carried long distances from the source of power. Hence these furnaces are called "induction furnaces." The Roechling-Rodenhauser furnace has, in addition to the induced current, a current passed through the metal from electrodes buried in the walls.

The induction furnaces have the advantage over the arc or electrode furnaces, of avoiding all troubles due to the flaking off of the electrodes and consequent indeterminate carburizing of the metal at inconvenient times. But today the manufacture of electrodes seems to have been so far perfected that this trouble has ceased to be serious, unless perhaps in case of the Stassano furnace in which gravity throws a serious stress on the outstretched horizontal electrodes. The induction furnaces may, perhaps, have a further advantage in avoiding the local high heating of the molten steel where the arc strikes it. It is possible that this local heating, to which in the arc furnaces one part of the metal after another

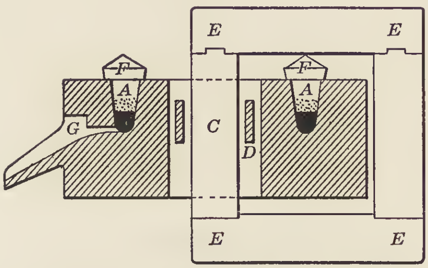


FIG. 5. KJELLIN INDUCTION FURNACE.
A A, circular trough in which steel is melted and treated. *C*, magnetic core. *D*, primary coil. *E*, frame connecting ends of *C*. *F* cover for melting chamber. *G*, spout.

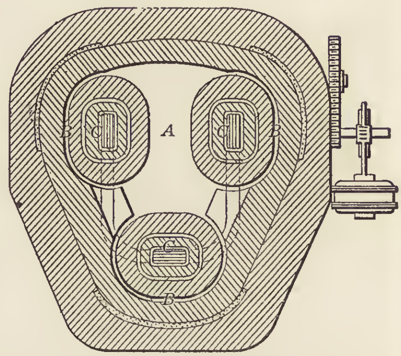


FIG. 6. ROECHLING-RODENHAUSER INDUCTION FURNACE.
A, basin for molten lead. *B*, three narrow channels in which the steel lies. *C*, three cores and coils for inducing current in the steel.

may be exposed, may cause some injury; but this is purely a matter of speculation.

On the other hand the induction furnaces now in use have limitations of their own. The Kjellin furnace consists of an annular trough which holds the molten metal, and in this ring of metal a current is induced by means of a central core. Now it appears that in order that any large fraction of the inducing current shall be utilized, this ring of metal must be of very small diameter, i. e., that the furnace must be on a scale so small as to put it almost out of the race.

A natural objection to the induction furnaces is that they do not melt their slag thoroughly, because they generate their heat within the metal, which in turn heats the slag, with the consequence that the slag is always cooler than the metal, instead of being hotter, as it should be, and actually is in the open-hearth furnace and probably in the electric-arc furnaces. Now in the normal practice of the electric furnaces, when a slag has become befouled with phosphorus or sulphur, it is removed carefully and thoroughly lest it later yield back its foulness to the purified metal. In the narrow ring of which the melting chamber of the Kjellin furnace consists, the removal of the slag is so difficult that the furnace is ill-suited for purification, and it is no doubt this fact that has given rise to the current idea that it is impossible to purify in the induction furnaces. This may be true of the Kjellin furnace, but it is clearly absolutely untrue of the Roechling-Rodenhauser furnace. I have before me the analysis of 17 consecutive heats made in one of these furnaces in which the initial phosphorus content of from 0.035 to 0.085 per cent. was reduced in 12 heats to traces, in four heats to 0.01 per cent. or less, and in one heat to 0.012 per cent. In another set of 25 consecutive heats the sulphur was reduced from between 0.048 and 0.097 per cent. in 15 heats to traces, in three heats to less than 0.02 per cent., and in seven heats to between 0.02 and 0.032 per cent. One would naturally fear that the narrow channels of this furnace would be likely to entrap part of the slag; but these excellent results lead us to believe that this is not necessarily true when the conditions are favorable. Thus, if this furnace is really under any disadvantage in this respect, it can only be that it has less perfect control over the purification than arc furnaces have.

Neither of these induction furnaces seems well suited for melting down cold charges, because it is only in a molten charge that the current is readily induced. The Roechling-Rodenhauser furnace seems to be further unfitted for the work of melting cold charges by the apparent vulnerability of its internal walls surrounding the cores. One naturally fears that, after these walls have become brittle through repeated heatings and coolings, the workmen will be very likely to damage them in charging cold scrap in irregularly shaped pieces. But to this objection I attach little weight. I do not think that any electric furnace should be used for melting down, because this work can be done so much more cheaply in a cupola or open-hearth furnace.

Beyond this the cost of installation and probably that of repairs is greater, and the consumption of electricity rather less in the Roechling-Rodenhauser than in the arc furnaces.

Another feature of the induction furnaces, the effect of which remains to be examined with care, is the rapid rotation of the molten metal, brought about by the action of current. How is this swift movement going to effect the removal of the suspended matter, slag, etc., from the molten metal? This, I think, must depend on the fluidity and cohesiveness of that matter. If it is dry and non-coherent, then its removal must be brought about by giving it a chance to rise slowly to the surface by gravity, and such a slow separation is opposed by this rapid motion of the metal, quite as the clearing of roily water would be by stirring it up, or the settling of dust would be by a high wind. But if the suspended matter is sticky, then this motion may assist its removal just as churning hastens the separation of butter, by helping it mechanically to coalesce into particles large enough to swim upward strongly. The solution of this trouble would seem to be: (1) to give the suspended matter such composition as to make it sticky; (2) to put the bath into motion, as by poling or by circulation which occurs in these induction furnaces, so as to aid mechanically the process of coalescing; and (3) to give quiet at last, so that the particles which thus have coalesced may rise to the surface.

Comparison of Furnaces.—To sum this comparison up, if these furnaces are used for their normal work of completing the purification begun in the open-hearth furnace or bessemer converter, there really seems but little to choose between them, if we except the Kjellin furnace, the usefulness of which seems very limited. The electrode furnaces have their electrode troubles, which are likely to be at their worst in the Stassano furnace. In the other electrode furnaces this trouble seems now to have been reduced within reasonable limits. There remain the cost of the electrodes, always a serious item, the possibility that the high heating opposite the arc may cause some permanent injury to the metal, and probably a slightly greater consumption of electricity than in the Roechling-Rodenhauser furnace. Against these slight disadvantages of the arc furnaces are to be weighed their probably somewhat better control over the purification in case the highest purity is aimed at; their smaller cost for installation and repairs, and perhaps their more complete removal of suspended matter because of the quiescence of their metal. Really, there seems but little to choose.

If cold charges are to be melted, the induction furnaces seem out of the race, and the violent oscillations of the current in the Stassano and Heroult furnaces would rather turn one's choice toward the Giffre or the Girod furnace.

Discussion.—We are now in a position to take up the discussion of the metallurgical principles which underlie the various purification processes, whether the furnaces in which they are carried out are heated by electricity or by other means. Indeed, the main purpose of this present article is to add, if possible, to the already clarifying effect of Mr. Coussergues' work. The discussion may be divided into that concerning the oxidizing stage of the process in which phosphorus is removed by means of iron oxide; and the deoxidizing stage in which sulphur and iron oxide are removed, together with suspended solid matter, and probably also together with hydrogen and nitrogen. The removal of the iron oxide may be begun by means of the usual reagents, carbon, ferro-silicon, aluminum, etc.; it is completed together with that of the sulphur by means of calcium formed in the process itself.

Dephosphorization.—Mr. Coussergues remarks that the chemical composition of slags does not in and by itself give a fair basis for dividing them into those which do and those which do not dephosphorize,[1] because whether dephosphorization shall occur depends on other conditions in addition to the composition of the slag. A slag which will absorb phosphorus from an oxidized bath will not absorb it from an unoxidized one. Now, while it is perfectly true that whether dephosphorization shall or shall not occur depends upon the balance of several opposing forces, yet I wish to point out that we can simplify the matter considerably by discriminating between slags which actively dephosphorize and those which are simply retentive of phosphorus, or in short, into the dephosphorizing and the nondephosphorizing on one hand, and the retentive and the irretentive on the other. Phosphorus cannot in general be removed except by oxidizing it. Hence a very basic lime silicate without iron oxide, made fusible by means of fluorspar, cannot appropriately be called dephosphorizing, because it has no strong power of oxidizing the phosphorus; yet it may be very retentive of phosphorus, so that if phosphorus is oxidized in presence of such a slag, it will be removed from the metal permanently.

It is from this point of view that I have said that silicates and phosphates of iron are more dephosphorizing for like basicity than those of lime. Those of iron play the double part of carrying oxygen from the atmosphere to the phosphorus, or, if put to it, of giving up their own oxygen to that phosphorus, which lime cannot do, and also of retaining through their basicity the resultant phosphoric acid. Mr. Coussergues cites[2] one effective way in which the ferruginous slags do this, by impregnating the metallic iron itself with iron oxide, and thus placing this oxide most advantageously for oxidizing the phosphorus dissolved alongside it in the iron, and, therefore, exposed to it, ion to ion. But this is only one feature of the oxidizing power of ferruginous slags which gives them their advantage over the calcareous ones. The ferruginous slags are strong both in oxidizing phosphorus and in retaining the resultant phosphoric acid; the calcareous ones are strong only in retaining the phosphoric acid which some other agency has formed.

---

[1] *Rev. de Métallurgie* (1909), VI, 641.
[2] *Ibid.*, (1909), VI, 647.

Mr. Coussergues properly points out the need of a formula[1] for expressing the relation between the several conditions, including the composition of the slag, and the strength of the dephosphorizing action to which they lead, and says reasonably that such a formula is likely to be based on the law of maximum work. For instance, the ratio between the phosphorus which enters the slag and that retained by the metal is likely to depend upon the heat generated by the formation of the phosphate, and the absorption of evolution of heat caused by the simultaneous reduction of the basicity of the slag. To this I would add that the law of mass action is likely to have a very important effect. I am sometimes tempted to call this the railroad-lunch-counter law. Here is a lunch counter spread with various things. Some of these we like much, some we like but little, some we barely tolerate, others we almost abhor. If the counter is not crowded, I select solely those things which I like best; it if is crowded enough, if I am hungry enough, and if the train is to start soon enough, I may be forced to eat those things least attractive to me, if the attractive viands are scarce and hidden behind masses of less tempting ones. So with my neighbors, and so with the processes of oxidization, reduction and the rest. If the oxygen comes upon the scene but slowly, it may select almost rigidly the most attractive element, i.e., it may form almost solely the combination which will yield the most heat. But let it rush through, and like a rough crowd at a lunch table, many molecules will snatch what they can get in their hurried passage, even if it is relatively unattractive, i.e., if the combination yields relatively little heat. This mental picture often helps.

The Oxidizing Period.—Mr. Coussergues points out that this hardly differs materially from the corresponding period of the basic open-hearth process, unless it is in the fact that that fear of over-oxidizing the metal which is ever before the open-hearth melter, basic or acid, does not trouble the electric-furnace melter, for the simple reason that, in the following deoxidizing period, the deoxidizing conditions are so strong that he can undo any degree of over-oxidation, no matter how great. Hence the electric-furnace melter can push his dephosphorization, by rapid oreing, as the open-hearth melter cannot.

But we have to be guarded even in going as far as Mr. Coussergues does in favor of the electric furnace. The electric-furnace slag richest in iron which he cites, contains only 56.36 per cent. of the combined oxides of iron and manganese (metallic oxides for short), which is not appreciably more than the reaction slags of the Monell open-hearth process contain at times without danger of over-oxidation of the metal.

[1] *Rev. de Métallurgie* (1909), VI, 643.

The difference betwen the two cases is that the metal which accompanied this electric-furnace slag had but little carbon, 0.05 per cent.; whereas that in the Monell process is much richer in carbon. Therefore, to speak accurately, if the metal is low in carbon the electric furnace enables us to ore more rapidly than we could in the open-hearth furnace; but I see no reason to think that it has any advantage even in this respect in case the metal is relatively rich in carbon, for then the rate of oreing is limited only by the resultant frothing. At best this advantage can hardly compensate for the much greater cost of the electric treatment.

In order to remove a large quantity of phosphorus, as, for instance, in making low-phosphorus steel from materials rich in phosphorus, several successive slags should be used. Here again, as in the Monell process, the first slag may be made rich in iron, so that it will take out the great bulk of the phosphorus, and may then be resmelted in the blast furnace, though, of course, if this were done on a large scale, it would continuously increase the phosphorus content of the pig iron, a trouble which hangs over the Monell process. The final dephosphorizing slag once the metal itself is well charged with oxygen, may be relatively poor in iron and rich in lime. But here again it is not easy to see what advantage the electric furnace has over the open hearth.

As I have already pointed out, it is hard to see why it is worth while to use an electric furnace for dephosphorizing, because the basic open hearth does this same work so cheaply, and can be made to do it so thoroughly. The great accent that has been put on the possibility of making excellent steel in the electric furnace out of bad scrap seems, as far as phosphorus is concerned, very misleading. In short, the reason for the existence of the dephosphorizing stage of the electric-furnace process has yet to be shown.,

Deoxidizing and Desulphurizing.—It is in this part of the process that the great interest lies; here, indeed, the formation of calcium sulphide introduces something of a new departure in steel metallurgy proper, and enables us to push the desulphurizing much farther than has been possible hitherto. For instance, with the best selected coal, the skilful French open-hearth men have not been able to reduce the sulphur below 0.02 per cent. In this country it has been found hard to reduce it to 0.025 per cent., and 0.03 per cent. is about as low as is attainable in common work, so fast is sulphur taken up from the flame. But in the electric furnace by forming calcium sulphide the sulphur can be reduced to mere traces. As to the importance of this reduction from 0.025 per cent. to traces, I shall have something to say later on.

If there has been an oxidizing stage, the first step after it is to remove with great care the phosphoric slag then formed, lest its phosphorus be deoxidized in the deoxidizing stage, and thus returned to the bath. For instance, in the electrode furnaces the electrodes may be withdrawn, and the slag thickened with lime or otherwise, so that it may be skimmed out completely.

Next comes the rough deoxidizing, brought about very much as in bessemer and open-hearth practice, by additions of carbon, silicon, manganese, or aluminum. As Mr. Coussergues points out, carbon should be used for removing the first of the oxygen, and the more expensive reagents should be used only for the last of it. He seems to think that carbon is intrinsically unable to finish the deoxidizing, and cites the large quantity of oxygen, at times enough to cause redshortness, that remains in steel recarburized by the Darby process, in which the oxidized products, the blown metal of the bessemer process, and the ored metal of the open-hearth process, are recarburized by bringing them into contact with solid carbon. But the fact that the very brief contact of the Darby process leaves much oxygen in the metal does not necessarily prove that prolonged contact with carbon, such as can be had in the electric furnace, is incompetent to remove the whole of the oxygen. There are indeed special circumstances under which carbon cannot be used, for instance, in the Kjellin furnace, in which the upper surface of the slag may be so viscid that carbon cannot act upon it. In that case the fusible ferrosilicon, thrown on in pea-sized lumps, melts and finds chinks through which it can work down. In the use of the Roechling-Rodenhauser furnace, as I understand, this difficulty can be got over if necessary by breaking through the crust of slag in its large basin.

But in the electrode furnaces the action of carbon, thrown upon the metal, or upon the very basic slag now formed by adding lime, or lime and sand, can be prolonged. Now if, as seems clear, carbon can reduce lime by the reaction (1) $C+(FeMn)S+CaO=CaS+FeMn+CO$, it is hard to understand why that same carbon cannot deoxidize iron oxide completely.

The natural mechanism of this deoxidation is that the oxides of iron and manganese start to distribute themselves between metal and slag according to the coefficient of distribution corresponding to the existing conditions, such as temperature and composition of slag and of metal; and that the retort carbon or other form of carbon thrown upon the molten slag reduces the oxides of iron and manganese which have entered that slag, thus opening the door for the entry of other lots of those oxides. An alternative way would be to begin the deoxidation with pure

Swedish pig iron, which should work very quickly, and to follow it up with carbon.

Desulphurizing.—After the deoxidizing is nearly complete, comes the desulphurizing by reaction (1) just given, and probably, in case ferrosilicon is used by the similar one (2) $2(FeMn)S+2CaO+Si=2CaS+2(FeMn)+SiO_2$. Clearly neither of these reactions should occur as long as any important quantity of oxide of either iron or manganese remains, because such oxide would yield its oxygen to the carbon or silicon far more readily than the lime would. In point of fact the Remscheid engineers maintain that the slag should not contain more than 1 per cent. of the oxides of iron and manganese jointly.

Desulphurizing by Distribution.—These sulphides of iron and manganese tend to pass into the slag, i.e., to distribute themselves thus between metal and slag, in a ratio called the "coefficient of distribution," which varies with the attendant conditions. It has been held that in a general way this coefficient increases with the temperature and with the percentage of lime in the slag, and decreases with the percentage of iron oxide in the slag. In other words, the higher the temperature, and the more lime and the less iron oxide the slag contains, the greater will the sulphur content of the slag be and the less will that of the metal be when the sulphur shall have distributed itself according to the then existing coefficient of distribution. Sulphur thus brought into the slag may escape thence by burning to sulphurous acid at its surface.

In view of this, the presence of metallic oxides (oxides of iron and manganese), of course, does not prevent sulphur from passing into the slag in the form of sulphide of iron or of manganese. Thus, one of the slags which Mr. Coussergues gives contains 6.35 per cent. of ferrous oxide and 11.16 per cent. of manganous oxide, or together 17.51 per cent., yet it has also 0.21 per cent. of sulphur. But, while the first of the sulphur can thus be slagged by "distribution," it is very slow work to reduce the sulphur to below 0.02 per cent. in this way. If, under favorable conditions, the coefficient of distribution rises to 5, so that the passage of sulphur from metal to slag might theoretically go on till the percentage of sulphur of the latter was five times as great as that of the former, then starting, say with 0.05 per cent. of sulphur and with a slag weighing one-fifth as much as the metal, the slagging of sulphur would cease when the sulphur content of metal and slag respectively had reached 0.025 per cent. and 0.125 per cent. Moreover, this slagging would grow extremely slow as this limit was approached, so that before reaching it the slag should be withdrawn and replaced with a fresh one. If this were done when the metal still contained 0.035 per cent. of sulphur, then the lowest point to which the sulphur could theoretically be reduced by this fresh slag would be 0.0175 per cent., and so on. Thus the removal of the last of the sulphur goes on ever more and more slowly.

But, if the slag and metal are so free from oxides of iron and manganese that lime can be deoxidized and calcium sulphide formed, then the desulphurization is rapid and may be made complete, because the resultant calcium sulphide, instead of merely distributing itself between metal and slag in a limited ratio, seems to pass wholly into the slag, or if not absolutely wholly, then at least in a very much greater proportion than the sulphides of iron and manganese do. Thus one of the Völkingen slags quoted by Mr. Coussergues contains 125 times as much sulphur as the underlying metal. The sulphur content of the slag is 2 per cent. that of the metal, 0.016 per cent.

The symptoms by which the formation of calcium sulphide is recognized are (1) that the slag becomes snow white, and (2) that it breaks down to a powder on cooling. Both these things are evidence that the slag contains no important quantity of the oxides of iron and manganese, but the slacking does not prove that the lime content is very high, as is often thought. As the presence of these oxides is the only obstacle to the formation of calcium sulphide and the thorough removal of the sulphur, these signs of their absence are accepted as proving that this strong desulphurizing has begun. But, as we wish not simply to begin, but to complete it, the desulphurizing action should be prolonged for, say, 45 min. after these symptoms have become marked. During this time the consumption of electricity should be hardly more than that needed to make up for the losses by radiation, because the temperature remains practically stationary, and because no important endothermic chemical change occurs.

It is asserted that the carbon thrown upon the slag for forming the calcium sulphide has no important effect in carburizing the metal.

Degree of Basicity Needed for Desulphurization.—In the iron blast furnace basicity of slag certainly favors desulphurization, but even here the basicity should be held within such bounds that the slag remains fluid enough to change quickly its surface of contact with the iron, the place where desulphurization occurs. In the basic open-hearth furnace, too, the slag is habitually kept as basic as possible, by adding lime just fast enough to keep some lumps of it unabsorbed and protruding above the molten slag. And certainly it is true that, if lime is to be reduced, it should not be held too tenaciously by the silica, and plenty of it should be exposed to the carbon which is to reduce it, two ways of saying that the slag should have plenty of lime. Again, as already pointed out, there is good reason to believe that the coefficient of distribution of manganese sulphide, i.e., the ratio of the sulphur content of the slag to that of the metal, increases with the lime content of the slag. But inferences from these facts should be drawn cautiously. In the first place, what would be very calcareous for a blast-furnace slag would not be for a basic open-hearth or electric-furnace slag. In the second place, the crowding of lime into the common open-hearth slag is rather for dephosphorizing than for desulphurizing. In the third place, though richness in lime may favor the passage of manganese sulphide into the slag, it does not at all follow that it strongly favors the formation of calcium sulphide. In short, the conditions in the electric furnace are so unlike those of the blast furnace, and the mode of removal of sulphur is so radically different from that of the basic open hearth, that the experience with those furnaces is not a good guide for the electric furnace.

Turning now to the data which Mr. Coussergues gives, we find not only that the sulphur content of the slags bears no relation whatsoever to their basicity, but that the least basic but one, with only 2.08 molecules of base per molecule of acid, i.e., barely a bibasic silicate (singulosilicate), has as much as 1.06 per cent. of sulphur.

I rearrange his data as shown in Table 1.

TABLE 1. DESULPHURIZATION DOES NOT DEMAND GREAT BASICITY OF SLAG

Ratio of basic to acid molecules....	5.083	3.925	3.667	3.572	3.429	2.828	2.472	2.154	2.081	1.56
Sulphur content of slag............	0.75	1.48	1.47	0.06	2.00	0.21	0.44	1.26	1.06	0.04

Though it is noteworthy that the only one of these which is less than bibasic, with a molecular ratio of base to acid of only 1.56, contains very little sulphur, only 0.04 per cent., yet we must set against this the fact that blast-furnace slags which are much less basic may yet contain much sulphur. In two cases given by Mr. Coussergues the ratio of the molecules of base to those of acid was 1.437 and 1.60,[1] yet the sulphur content was 3.90 per cent. in the first and 2.56 in the second.

In Table 2 I give several blast-furnace slags which contain a considerable quantity of sulphur, in spite of having much less lime and magnesia than basic open-hearth slags do. Thus, it may be found practicable to desulphurize in the electric furnace without recourse to strongly basic slags; indeed, one does not see at first any difference in conditions between the blast furnace and the electric furnace competent to prevent the very moderately basic slags which can desulphurize in the former

[1] Mr. Coussergues gives this as 0.889, but I calculate it as 1.60.

from doing like work in the latter. The desulphurizing slags in both cases are almost free from oxides of iron and manganese; the temperatures are not far apart; and the actual contact between carbon and slag is common to them, and need not be limited in extent in the electric furnace, so far as one can see.

TABLE 2. SULPHUR IN BLAST FURNACE SLAGS NOT STRONGLY BASIC

No.	CaS.	S.	SiO_2.	Al_2O_3.	CaO.	MgO.	Reference.
1.	0.38	0.17	66.90	14.08	12.24	4.48	W. Matheisus, *Stahl u. Eisen* (1908), XXVIII, 1122, 1125; also *Rev. de Métallurgie* (1909), VI, 144, 147.
2.	4.75	0.78	47.94	12.01	31.20	4.36	
3.	2.10	0.93	45.57	7.35	33.20	6.13	
4.	4.39	1.95	27.65	24.69	36.56	3.55	
5.	7.76	3.44	33.10	24.56	25.92	6.97	
6.	....	0.24	42.15	11.02	43.00	1.25	R. H. Sweetser, *Iron Age* (1908), LXXXII, 446.
7.	....	1.23	35.00	11.17	46.40	4.68	My private notes.
8.	2.17	0.96	35.20	10.02	47.10	1.20	Jantzen, *Stahl u. Eisen* (1903), XXXIII, 362.
9.	....	0.08	49.57	9.00	.....	15.15	H. H. Campbell, "The Manufacture and properties of Iron and Steel," 2d Ed. (1903), 52.
10.	....	0.08	48.39	6.66	.....	10.23	

The observation of Völklingen that an accidental addition of sand which thinned the slag and was followed by a strong smell of sulphurous acid, increased the desulphurization so that only 0.04 per cent. of sulphur remained[1] is interesting, and deserves a certain weight. But its importance is easily overrated, because, while we will all admit that such extreme basicity as makes the slag so viscid that its surface of contact with the bath does not quickly renew itself, is harmful, yet what we are now considering is the effect of basicity within the limits of good fluidity, on the removal of sulphur as calcium sulphide. It is very doubtful whether any such removal occurred in this particular case, because desulphurization by distribution, through the action of manganese sulphide, could easily reduce the sulphur to the percentage, 0.04 per cent. here reached.

Influence of Manganese on Desulphurization.—The belief of some metallurgists that manganese hastens desulphurization has been opposed with evidence which, as Mr. Coussergues says, seems quite incompetent.[2]

[1] Professor Osann, *Stahl u. Eisen* (1908), XVIII, 1018.

[2] Professor Osann gives the results of two heats in the Roechling-Rodenhauser furnace at Völklingen, in which addition of ferro-manganese so large as to put 0.96 and 0.64 per cent. of manganese into the metal, yet left 0.053and 0.044 per cents of sulphur in the slag (*Stahl u. Eisen* [1908], XXVIII, 1019, 1021). But these additions of ferromanganese were made immediately after the end of the oxidizing period, when the metal was sure to have been charged with oxygen, and the slag was sure to have contained much oxide of iron and manganese jointly. For the first of these heats the composition of the slag at that time is not given; but its final slag contained 8.12 per cent. of oxides of iron and manganese, in spite of the addition of ferrosilicon meanwhile; and the final slag of the other heat contained 11.30 per cent. of iron oxide and 5.88 per cent. of total manganese (not manganese oxide), or say more than 18 per cent. of oxides or iron and manganese jointly. No wonder that the sulphur was not fully removed under these conditions.

The defect in the evidence is that in those of its cases in which the desulphurization was incomplete in spite of the presence of manganese, the slags themselves contained enough oxide of iron and manganese jointly to prevent desulphurization. In order to understand this we must bear in mind the true role of manganese which I have already explained. Its direct action seems to be confined to carrying sulphur into the slag by distribution in the form of MnS. As already pointed out, though it may in this way remove the first of the sulphur readily, it can remove the last only slowly. Certainly we cannot expect it to go beyond this desulphurizing by distribution, and actually lead to the formation of calcium sulphide and thereby to rapid and complete desulphurization, simply because we cannot expect it to deoxidize lime, a thing, of course, absolutely necessary to the formation of calcium sulphide. In the presence of sulphide of iron or manganese, lime can be deoxidized by carbon, silicon, and probably by aluminum and by silicide of calcium, but neither by iron nor manganese.

But manganese may hasten the formation of calcium sulphide in a very simple and effective way. It seems perfectly clear that manganese oxide and sulphide pass from metal to slag far more rapidly than iron oxide and sulphide do. Indeed, one is often tempted to give it as a general law that the metals retain their own oxides and sulphides far more strongly than they retain those of other metals. Now carbon and lime can do their work of desulphurizing by reaction (1) only as fast as these metallic sulphides are brought before them in the slag, and only on the condition that the whole mill is not thrown out of gear by the presence of oxide of iron or of manganese in that slag. The presence of manganese certainly hastens the removal of iron oxide by carrying its oxygen from the metal to the deoxidizing action of the carbon floating on the slag, and thus gradually slides the mill into gear; and it hastens the movement of grist to the mill by hastening the transfer of sulphur as manganese sulphide from metal to slag. Evidence that manganese does not cause immediate desulphurization of slags which are rich in oxide of iron or manganese only shows us what should not surprise us, that the wagon which brings grist to the mill cannot by itself jerk the mill into gear.

Influence of Temperature on Desulphurization.—The opinion of many electric-furnace metallurgists that low temperature favors deoxidization and desulphurization does not really conflict with the well-established fact that a high temperature in the blast furnace favors desulphurization by the formation of calcium sulphide, because in the blast furnace it may not be the high temperature as such, but the attendant conditions that are responsible. One of these conditions, as Mr. Coussergues points out, is absence of metallic oxides from the slag; a second is the presence of silicon in the molten iron, which at the junction of slag and metal may well co-operate with the lime of the slag to desulphurize by reaction (1).

But further evidence is needed. If, as seems very probable, high temperature favors the retention of iron oxide by the metal, by increasing its solubility in the metal or otherwise, that in itself would retard the freeing of the metal and slag jointly from metallic oxides in the electric furnace, and in this way would lengthen the operations of deoxidizing and desulphurizing taken together. With our present knowledge it is not so easy to discriminate between the effects produced on these two essentially distinct phases by variations in the attendant conditions such as temperature. If it is really true that deoxidation and desulphurization taken jointly are favored by a low temperature, that may well be one reason why they are not favored by strong basicity of slag, because a very basic slag needs a high temperature to keep it fluid enough for active work.

Removal of Hydrogen and Nitrogen.—Electric-furnace steels examined by Guillet contained less nitrogen and especially less hydrogen, not only than open-hearth steel, which is natural enough in view of the exposure of the latter to the atmosphere in the open-hearth furnace, but also than crucible steel, which is rather surprising. Mr. Courssergues reasonably suggests that the relative freedom from hydrogen may be due to the formation of acetylene or other hydrocarbon at the surface of contact of contact of metal and slag by the reactions $Ca+2C=CaC_2$, and $CaC_2+2H=Ca+C2H_2$.

Separation of Slag.—The conditions in the electric furnace may well lead to a more thorough separation of the slag and like suspended solid matter than is possible in the open-hearth process. Here the deoxidizing additions are made at the very end of the operation, just before the metal is tapped out of the furnace, or, as is too often the case, as the metal runs from furnace to ladle, so as to avoid any long exposure to the necessarily oxidizing conditions, which partly undoes the work of deoxidation and so increases the consumption of deoxidizers. But each of these deoxidizing additions gives rise to a harmful product, carbon to carbonic oxide which may form blowholes, manganese to manganous oxide which may later form them by reacting on the carbon of the metal, and silicon and aluminum to silica and alumina in a very fine state of division. Though we have not worked out thoroughly the conditions necessary for freeing the metal from these suspended substances and from dissolved carbonic oxide, there is probably good ground for the complaint that "we make too much steel in the ladle," i.e., that we do not give time enough for letting these harmful products of our deoxidizing rise to the surface and escape into the slag or the atmosphere.

Now note what advantage the electric furnace, with its strongly deoxidizing conditions, has in this matter over the open-hearth furnace with its strongly oxidizing atmosphere.

(1) Because the metal is thoroughly deoxidized by carbon thrown upon the slag, the final additions have very much less deoxidation to do and hence the quantity of harmful products of that deoxidation is very much smaller than in the open-hearth process, indeed hardly more than what is implied by the slight oxidation in passing from furnace to mold.

(2) The absence of oxidizing conditions leaves the metal in the electric furnace quiescent, with the best possible opportunity for any suspended matter to rise by gravity and escape from the metal, whereas in the open-hearth furnace the oxidizing atmosphere, ever generating iron oxide which forms carbonic oxide with the carbon of the steel, keeps the bath in a boil which, even if it is relatively slight, may be expected to oppose the separation of suspended matter. Bue here we must speak guardedly, for the reasons pointed out, in comparing the electrode and the induction furnaces with regard to the removal of suspended matter.

(3) In the electric furnace the absence of oxidizing conditions enables us to hold the molten charge long after the deoxidizing additions, in order to enable the suspended matter to separate, without fear of rapid change of composition, whereas the oxidizing conditions in the open-hearth furnace bring about such rapid changes of composition that only the most skilful can hold the charge in the furnace long after making the final additions without great and indeterminate changes in composition. In the open-hearth furnace our game is on the wing; in the electric furnace it is on the bough.

Mr. Coussergues thinks that the greater time available in the electric furnace for the separation of suspended matter by gravity is of little value, because this separation is in any event so rapid. If he has good evidence to prove this it will be welcome. The large quantity of slag which we so often find in our steel hardly prepares us for this belief. Certainly our natural expectation is that this extremely finely divided matter, which, as we find it in the sides of the pipe is an impalpable powder, should be very slow in rising, if we may reason from the time which cream takes to rise from milk and roily water takes to clear itself.

Summary.—Looking back, we see that, as an instrument for melting and dephosphorizing, the electric furnace has no advantage over the cupola and open hearth, certainly none which can compensate for the great cost of its heat. It is in its thorough deoxidizing and consequent thorough desulphurizing, its removal of suspended matter, and probably of hydrogen, that the electric furnace is at an advantage.

Looking a little closer one naturally asks whether the reduction of sulphur and phosphorus from 0.025 per cent. to any smaller quantity is, in and by itself, enough either to pay for the great cost of the electric treatment or to make the steel materially fitter for any but the most trying uses. We are rather inclined to refer a very large part of the superiority of electric steel to open-hearth steel to its greater freedom from oxide, from suspended slag, and perhaps from hydrogen and nitrogen. But whatever its elements of superiority may be, it seems pretty clear that they are directly or indirectly the result of the strong deoxidizing conditions in the deoxidizing and desulphurizing part of the process, in short, to the freedom of its atmosphere from oxygen.

LEAD.

The production of lead in the United States in 1909 increased largely, the total of the refined product exceeding the highest figure previously on record. Statistics of production, based upon returns from all of the refiners, are given in the accompanying tables. The explanation is necessary that, as in previous years, the statistics represent especially the production of the smelters and refiners whose business is mainly the treatment of ores and of lead derived directly from ores, but nearly all of them receive more or less scrap and junk which goes into their charges and reappears along with the virgin lead and for all practical purposes itself becomes virgin lead. There is also in the United States a large production of reworked lead by smelters who make that a special business, which is not included in the primary statistics. In the classification of the production the output of two smelters in Illinois is included under "Southeast Missouri," and the output of the single smelter in Kansas under "Southwest Missouri," as the ore which they use is chiefly derived from these districts. "Desilverized" does not include the lead, chiefly of Missouri origin, which is desilverized by one smelter in Illinois and which is entered under "Southeast Missouri."

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Domestic Origin.						Foreign Origin.		Grand Total.
	Desilverized.	Antimonial	S. E. Mo.	S. W. Mo.	Miscel.	Total.	Desilverized.	Antimonial	
1905	205,665	8,456	81,299	21,324	3,000	319,744	83,504	2,730	405,978
1906	220,095	7,434	100,492	16,528	980	345,529	67,441	2,686	415,656
1907	213,383	9,614	108,510	17,833	790	350,130	76,016	(a)	426,146
1908	174,650	13,109	113,103	18,014	*Nil.*	318,876	94,992	(a)	413,868
1909	211,499	10,392	126,784	20,489	*Nil.*	369,164	89,681	2,338	461,183

(a) Entered under domestic antimonial.

In the table which gives the production of lead, according to States, the statistics are based, so far as possible, upon the reports of the producers of work-lead (or base bullion), which bears the same relation to refined lead that blister copper does to refined copper. Consequently, it is not to be expected that these totals should agree with the totals representing refined lead production. Difference may arise through in-

STATISTICS OF LEAD IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Produced from Domestic Ores.				Imported in Ores and Bullion. (c)	Total Production and Imports.	Exported in all Forms.
	Desilverized.	Soft. (a)	Antimonial. (b)	Totals.			
1897	144,649	45,710	7,359	197,718	92,117	302,859	60,353
1898	169,364	50,468	8,643	228,475	89,209	348,845	78,168
1899	171,495	40,508	7,377	217,085	76,423	317,196	74,944
1900	221,278	47,923	9,906	279,107	114,397	425,824	100,288
1901	211,368	57,898	10,656	279,922	112,471	458,033	100,026
1902	199,615	70,424	10,485	280,524	107,715	458,456	82,228
1903	188,943	78,298	9,453	276,694	106,407	418,601	81,971
1904	200,858	90,470	10,876	302,204	112,852	415,056	84,142
1905	205,665	105,623	11,186	322,474	98,378	420,852	59,741
1906	220,095	118,000	10,120	348,215	84,134	432,349	47,323
1907	213,383	127,133	9,614	350,130	79,815	429,945	51,502
1908	174,650	131,117	13,109	318,876	112,074	430,950	76,857
1909	211,499	147,273	12,730	371,502	114,182	485,684	86,077

(a) Since 1904 a large part of the so-called soft lead was desilverized, but this (being of Missouri origin) has been included in the old classification. (b) The entire production of antimonial lead is entered as of domestic production, although part of it is of foreign origin. (c) Includes "pigs, bars and old."

PRODUCTION OF LEAD BY STATES.
(In tons of 2000 lb.)

State.	1902 (a)	1903 (b)	1904 (b)	1905 (b)	1906 (c)	1907(c)	1908(c)	1909(c)
Arizona	599	1,418	1,424	1,986	2,884	2,200	1,867	1,304
California	175	52	155	110	432	850	490	865
Colorado	51,833	43,276	49,290	(f)57,856	(f)52,992	47,332	26,707	26,413
Idaho	84,742	94,611	103,411	(h)107,000	(i)121,584	111,697	98,394	97,137
Kansas	(n)	(n)	(n)	(n)	(n)	1,800	2,400	1,500
Missouri	(d)79,445	86,439	92,119	(g)102,500	115,103	123,613	125,216	146,829
Montana	4,438	3,138	3,454	2,097	2,485	2,005	2,309	1,331
Nevada	1,269	2,125	1,779	2,096	1,669	3,400	3,676	4,086
New Mexico	741	582	1,295	1,170	640	1,900	611	1,275
Oklahoma	nil	....	....	....	....	400	1,000	3,000
Utah	53,914	48,573	53,647	42,746	56,260	54,738	43,995	65,975
Wisconsin	....	....	....	....	1,753	3,500	3,486	2,745
Other States	(e)3,641	(k)2,188	(k)630	(k)2,695	(m)943	1,204	600	629
Undistributed	....	....	....	....	....	....	2,026	3,062
Zinc Smelters	....	....	....	....	....	1,320	1,290	2,796
Total	280,797	282,402	307,204	320,256	356,745	355,959	314,067	362,851

(a) Statistics of U. S. Geological Survey representing lead content of ore smelted. (b) U. S. Geological Survey figures giving production of "merchant lead." (c) Smelters' reports. (d) Includes production of Wisconsin, Illinois, Iowa, Virginia and Kentucky. (e) Includes production of Alaska, So. Dakota, Washington, Georgia, Tennessee and Texas. (f) Report of State Commissioner of Mines. (g) Includes 1500 tons from Iowa, Illinois and Wisconsin, but not the total production of those States. (h) Partly estimated. (i) Report of State Inspector of Mines less allowance of 5 per cent. for loss in smelting. (k) Includes production of Alaska, Oregon, So. Dakota, Washington, Georgia, Tennessee, Virginia, Kentucky and Texas. (m) Includes production of Illinois, Iowa, Kentucky, Tennessee and Washington. (n) Included with Missouri.

IMPORTS OF LEAD IN ORE, BASE BULLION, PIGS, BARS AND OLD. (a)
(In tons of 2000 lb.)

Source.	1901	1902	1903	1904	1905	1906	1907	1908 (c)	1909(c)
United Kingdom	201	396	776	247	795	4,926	217	(b)	(b)
Germany	336	476	705	366	125	1,003	228	(b)	(b)
Other European	1	671	226	83	59	1,961	3,461	(b)	(b)
Canada	26,065	9,732	9,600	8,952	8,182	9,257	6,663	644	2,063
Mexico	81,727	93,742	93,068	102,903	87,584	66,756	68,767	107,369	104,620
South America	4,109	2,690	1,948	290	1,577	158	442	(b)	(b)
Other Countries	32	6	83	11	56	74	63	1,273	4,422
Total	112,471	107,713	106,406	112,852	98,378	84,135	79,814	109,286	111,105

(a) Refined lead, i.e., in pigs, bars and old, is a small part of the total. It was in 1901, 604 tons; in 1902, 2,529 tons; 1903, 3,023 tons; 1904, 8,724 tons; 1905, 5,720 tons; 1906, 11,763 tons; 1907, 9,277 tons; 1908, 2,759 tons. (b) Included in other countries. (c) Figures do not include import of pigs, bars and old. With these the total imports for 1908 were 112,045 tons, and 114,182 tons in 1909.

creased accumulation of stock at works or in transit, or the opposite. Also, we fancy that to a more or less extent the refiners include in their reports of lead of domestic origin the "exempt" lead of foreign origin which heretofore has been admitted free of duty, and has been marketed as domestic lead. The table represents, as near as it is practically possible to determine, the source of the lead production in the United States. In the cases where it is possible to obtain reports of the mine production, it is uncertain as to what part of that production is actually recovered in smelting. Moreover, differences between mine and smeltery figures may be explained by differences in the stock of ore in transit or in the bins of the smelters.

The particularly noteworthy features of the statistics for 1909 are the large increases in the production of Missouri and Utah, while the output of Idaho and Colorado remained practically at a standstill. The lead output of Missouri in 1907, for the first time in recent years, exceeded that of Idaho. Missouri now holds, without question, the premier position among the lead-producing States of the Union. If we should limit ourselves further and say the lead-producing district of southeastern Missouri, our statement would still be true.

Looking at the situation statistically, which view is confirmed by knowledge of the mining conditions, it appears that the lead mines of the Cœur d'Alene have passed their zenith. Idaho, which is equivalent to the Cœur d'Alene, made its maximum production of 121,584 tons of lead in 1906. Since then the output has decreased annually. On the other hand, Missouri has been making uninterrupted gains for many years, and now, if we lump with Missouri the nonargentiferous lead-producing States of Kansas, Oklahoma and Wisconsin, they account for nearly 50 per cent. of the total lead production of the country. This lead is chiefly produced by concerns that are independent of the American Smelting and Refining Company, and from the present magnitude of their production, it can readily be seen why they are now so powerful a factor in the lead market.

The consumption of lead increased largely in 1909; business in white lead and oxides, which amounts to about 40 per cent. of the total, having been especially good. This caused the stocks in the hands of the refiners, rather large at the beginning of 1909, gradually to disappear, and at the end of the year there was probably scarcely more than an ordinary working surplus on hand.

The Payne law made no change in the tariff on lead in ore and base bullion, but an alteration in the section as to smelting in bond deprived the refiners of the "exempt lead" which formerly was a valuable perquisite. For the cancellation of bonds, the refiner is now obliged to deliver the lead actually produced, whereas, formerly he had to deliver only 90 per cent. of the base bullion imported, although he normally recovered 96 per cent. Consequently, he obtained the difference free of duty.

DELIVERY OF LEAD IN THE UNITED STATES.
(In tons of 2000 lb.)

	1905	1906	1907	1908	1909
Supply:					
Production desilverized	289,169	287,536	289,399	269,642	301,180
Production soft lead	105,623	118,000	127,133	131,117	147,273
Production antimonial lead	11,186	10,120	9,614	13,109	12,730
Imports foreign refined lead	5,720	11,763	9,277	2,759	3,576
Stock, domestic lead, Jan. 1	10,000	4,000	4,000	(e)50,000	(e) 75,000
Foreign in bond, Jan. 1	11,481	8,148	5,691	12,897	18,462
Total supply	433,179	439,567	445,114	479,524	558,221
Deductions:					
Re-exports of foreign	58,631	47,223	51,424	76,857	86,077
Exports of domestic lead	63	74	55	*Nil*	6
Stock, domestic, Dec. 31	4,000	4,000	(e)50,000	(e)75,000	(e) 94,430
Foreign in bond, Dec. 31	8,148	5,691	12,897	18,462	12,695
Total deductions	70,842	56,988	114,376	170,319	183,208
Delivery	362,331	380,122	330,738	309,205	(e) 351,000

(e) Partly estimated.

CONSUMPTION OF LEAD IN THE UNITED STATES.

Purpose.	1907		1908		1909	
	Tons.	%	Tons.	%	Tons.	%
White lead and oxides	115,000	34.8	117,500	40.5	134,138	38.0
Pipe	41,000	12.4	33,800	11.6	52,914	15.2
Sheet	21,500	6.5	16,400	5.7	23.421	6.7
Shot	28,000	8.5	31,600	10.9	36,433	10.4
Other purposes	125,238	37.9	90,700	31.3	104,094	29.7
Totals	330,738	100.0	290,000	100.0	351,000	100.0

LEAD PRODUCTION OF THE WORLD.
(In metric tons.)

Year.	Australasia.	Austria. (a)	Belgium.(a)	Canada. (a)	France. (a)	Germany. (a)	Greece. (a)	Hungary. (a)	Italy. (a)
1897	22,000	9,860	17,023	17,698	9,916	118,881	16,468	2,527	22,407
1898	67,000	10,340	19,330	14,477	10,920	132,742	19,193	2,305	24,543
1899	87,600	9,736	15,700	9,917	15,981	129,225	19,059	2,166	20,543
1900	87,100	10,650	16,365	28,648	15,210	121,513	16,396	2,030	23,673
1901	90,000	10,161	18,760	23,537	21,000	123,098	17,644	2,029	25,796
1902	90,000	11,264	19,504	10,411	18,817	140,331	14,048	2,243	26,494
1903	141,446	12,162	22,263	8,226	23,258	145,319	12,361	2,057	22,126
1904	118,979	12,645	23,470	17,241	18,800	137,580	15,186	2,104	23,475
1905	(c)104,639	12,968	22,885	25,391	24,100	152,590	13,729	2,146	19,097
1906	(d)93,000	14,846	23,765	24,580	25,614	150,741	12,308	1,925	21,268
1907	(d)97,000	13,598	27,450	21,660	24,800	164,079	13,814	1,468	22,978
1908	(d)119,009	12,669	35,650	19,593	26,112	164,079	15,892	1,544	26,003
1909	(d)77,200	(e)12,400	(d)41,300	20,819	(e)26,000	167,920	(d)15,300	(e)1,500	(e)23,000

LEAD PRODUCTION OF THE WORLD (Continued).

Year.	Japan. (a)	Mexico. (a)	Russia. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a) Foreign Ores.	United Kingdom. (a) Domestic Ore.	United States.	Totals. (f)
1897	1,737	71,637	450	189,216	1,480	13,312	26,988	179,369	720,969
1898	1,705	71,442	241	198,392	1,559	23,239	25,761	207,271	830,460
1899	1,989	84,656	322	184,007	1,606	17,571	23,929	196,938	818,945
1900	1,877	63,827	221	172,530	1,424	10,738	24,762	253,204	849,168
1901	1,806	94,194	156	169,294	988	19,639	20,361	253,944	892,407
1902	1,644	106,805	225	177,560	842	9,113	17,987	254,682	901,970
1903	1,728	(b)94,181	106	175,109	678	14,900	20,278	256,138	952,336
1904	1,803	(c)103,000	90	185,862	589	6,888	20,155	278,634	966,501
1905	2,272	(b)101,196	700	185,693	576	7,517	20,977	290,472	986,948
1906	4,305	(b)73,699	907	185,470	753	6,984	22,691	323,567	986,423
1907	3,067	(b)76,158	520	(d)185,800	813	10,880	24,850	322,854	1,011,801
1908	2,910	(b)127,010	523	188,062	277	11,480	21,336	284,858	1,057,007
1909	(d)3,000	(d)118,000	(e)500	(d)184,200	(e)300	(e)12,000	(e)25,000	334,900	1,063,139

(a) From official reports of countries unless otherwise denoted. (b) Exports. (c) Commercial statistics of Julius Matton, London. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated.

Lead Mining in the United States.

Colorado. (By George E. Collins.)—The production of lead in this State increased slightly in 1909. Leadville continued to be the chief district, but its production fell off greatly after the suspension of work in the downtown mines. A large output, however, was maintained from the Yak tunnel and the Iron-Silver company shipped on a large scale. Other notable shipments were from silver mines at Creede, Georgetown, and in the Summit county districts and also from the San Juan. The old Mary Murphy property at Romley, in the central part of the State, was acquired by an English company and may at some future time become a notable producer. The output for a series of years of the lead producing counties of the State is given in the accompanying table.

LEAD PRODUCTION OF COLORADO. (a)
(In tons of 2000 lb.)

County.	1901	1902	1903	1904	1905	1906	1907	1908	1909
Clear Creek	1,945	1,641	1,726	1,981	1,631	1,439	1,832	1,205	1,495
Hinsdale	3,705	3,107	230	521	446	442	470	82	50
Lake	28,180	19,725	18,177	23,590	26,424	23,918	17,032	7,169	7,061
Mineral	5,260	4,646	4,300	6,673	5,940	7,443	6,490	4,119	4,526
Ouray	3,952	2,131	1,675	1,022	2,674	2,861	1,803	1,516	1,354
Pitkin	16,375	12,487	16,635	9,441	10,987	8,781	6,957	3,713	6,315
San Juan	7,736	3,850	3,485	4,644	3,223	2,070	6,213	5,133	4,921
Others	6,813	5,565	4,529	5,901	6,531	6,038	5,696	5,918	6,638
Total	74,056	53,152	50,757	53,773	57,856	52,992	46,493	28,855	32,360

(a) As reported by the State Commissioner of Mines.

Idaho. (By F. C. Moore.)—In 1909 Idaho produced 97,137 tons of lead, of which 99 per cent. came from the Cœur d'Alene district in Shoshone county. Practically all of this lead was derived from argentiferous-galena ore. The ore of the Cœur d'Alene district occurs in fissure veins and zones, in Pre-Cambrian quartzites. The veins have been filled largely by replacement. First-class galena is produced, varying from 45 to 70 per cent. lead. The bulk of the ore is concentrated, the ratio of concentration varying from 5 : 1 to 12 : 1; the concentrates shipped run from 45 to 60 per cent. The ratio of silver to lead varies from 0.4 to 1 oz. per unit of lead. Idaho produces about 30 per cent. of the total lead of the United States and with the associated silver occupies a conspicuous place in the metal production of the world.

FEDERAL MINING AND SMELTING COMPANY. (*a*)

	1905	1906	1907	1908	1909
Tons ore mined	664,830	874,332	888,950	599,850	832,568
Average lead (*b*)	6.64%	7.21%	6.72%	7.33%	6.83%
Average silver, oz. (*b*)	4.05	4.48	4.15	4.68	3.74
Tons concentrate (*c*)	85,205	130,855	130,373	93,811	122,764
Ratio	7.8 : 1	6.7 : 1	6.8 : 1	6.4 : 1	6.8 : 1
Oz. silver	2,689,867	3,920,884	3,689,298	2,803,628	3,111,931
Average per ton	31.57	29.96	28.30	29.90	25.35
Tons lead	44,137	63,029	59,746	43,988	56,904
Average	51.8%	48.17%	45.83%	46.88%	46.34%
Net profit	$1,242,698	$2,685,300	$2,532,250	$1,067,037	$1,185,947
Dividends paid	1,098,896	1,647,457	1,917,741	928,917	928,921

(*a*) For fiscal years ending August 31. (*b*) Average yield, not average assay. (*c*) Includes mill concentrate and shipping ore.

The new mill of the Bunker Hill & Sullivan was completed and is now in regular operation. The old concentrators are being remodelled for reworking of the many thousands of tons of tailings.

The older producers in the district gave more study to the improvement of ore treatment methods. The Federal company is obtaining satisfactory results from the Hancock jig on fine ore. The experience of the Cœur d'Alene mills has shown that the Harz jig, as originally constructed and operated was susceptible of much improvement. Improvement has been largely achieved in classifying and jigging the finer sizes, using the Caetani jig, which appears to do as good work as the Hancock on the finer sizes. It also has the advantage of successfully separating all the slimes and sending them to the slime department directly from the first compartment, without traveling the length of the jig, and making further treatment necessary as the Hancock arrangement demands. Briefly it may be said that the old style of Harz jig will in a few years be entirely superseded by improved jigs of the type successfully used in some of the Cœur d'Alene mills, and by the Hancock jig for finer sizes.

The Cœur d'Alene mines have been successful in development in depth. The Bunker Hill & Sullivan mine is now 3000 ft. below the apex of its orebody. The Standard-Mammoth is working at 2750 ft. in excellent ore. The Hercules at Burke is working at 2000 ft. in depth with ore of high grade. The Morning mine at Sullivan is down more than 2000 ft. The Hecla mine at Burke is 1200 ft. below the surface. It is reported that at 2200 ft. in depth in the Tiger-Poorman mine the ore-shoots had contracted in width, but that there was a portion of the ore-shoot which gave indications that would justify explorations to several hundred feet more in depth.

During 1909 the Chicago, Milwaukee & St. Paul road completed its line to the Pacific coast. In Idaho the line extends through the southern border of the Cœur d'Alene district and affords an outlet for numerous copper, gold and lead-silver prospects in that section.

Missouri.—This State, which has been the largest lead producer in the United States since 1905, made an increased output in 1909. In the southeastern district the production was unusually large, amounting to 126,784 tons, which gives Southeastern Missouri the world's record as a district. When the production of the Joplin district in Southwestern Missouri is added, the production of the State exceeds that of Spain and gives Missouri the world's record. Developments in the Joplin district, where the lead is recovered as a by-product in working the zinc ore, are treated especially under the caption of "Zinc" later in this volume. The production of galena ore in this district for a series of years is given in the accompanying table.

PRODUCTION OF LEAD ORE IN THE JOPLIN DISTRICT.
(Tons of 2000 lb.)

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1895........	31,294	1898....	26,687	1901....	35,177	1904....	34,362	1907....	42,065
1896........	27,721	1899....	23,888	1902....	31,625	1905....	31,679	1908....	38,533
1897........	30,105	1900....	29,132	1903....	28,656	1906....	39,189	1909....	43,659

PRICE OF LEAD ORE AT JOPLIN
(Per ton of 2000 lb.)

Year.	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
Highest......	$56.50	$47.50	$50.00	$60.50	$62.00	$80.00	$87.00	$88.50	$66.00	$60.50
Average......	48.32	45.99	46.10	54.12	54.80	62.12	77.78	68.90	55.75	54.58

In January the average quotation on lead ore in Joplin was $51.74 per ton. The price fell off slightly in February and March, but in April there was a sharp advance, the average quotation for the month being $54.71. Prices continued to rise throughout May and June, the average price during the latter month being $57.92, the high average of the year. In July the average quotation was $54.19, but this was raised to $57.61 in August. During the fall months there was a gradual recession. The year closing with an average for December of $54.60 per ton.

(By H. A. Wheeler.)—The productive portion of the Southeast Missouri district is a belt about 75 miles long that includes the counties of Franklin, Jefferson, Washington, St. Francois and Madison. The heavy production of 1909 was derived from the deep, low-grade, disseminated deposits that occur in a basin in St. Francois county, 15 miles long by 7 miles wide, in which the principal towns are Bonne Terre, Flat River and Leadwood. Another basin of much less importance occurs in Madison county, about six by five miles in area, of which Fredericktown is the center. St. Francois county produced over 95 per cent. of the output, while Madison county produced about 4 per cent. and the remainder of the district, from the shallow diggings, produced less than 1 per cent.

That disseminated ore will be found underlying the present productive zones, there is scarcely any doubt. Prospecting for new orebodies with the diamond drill was carried on to only a moderate extent in 1909, and was entirely confined to the operating companies. Most of the drilling was done to develop the extensions of the working orebodies.

The St. Joseph company maintained its usual large production in 1909, but for the first time in its career the company took second place as its output was exceeded by that of the Federal Lead Company. The mills at Bonne Terre and Leadwood were both kept in full operation and the concentrates shipped to the smeltery at Herculaneum, 30 miles north of Bonne Terre, on the Mississippi river. The smeltery is equipped with five, large, mechanically fed shaft furnaces and a battery of five Savelsberg pots or roasting furnaces, besides the refinery and matte roasters. It is the intention to enlarge greatly the pot plant for roasting the concentrates, after which the 20 Freiberg or hand-roasting furnaces at Leadwood will be closed down. A new shaft, No. 15, was sunk on the southern part of the Crawley tract at Flat River and equipped with an electric hoist. As soon as the enlarged power plant of the Doe Run company at Flat River can furnish power, this shaft will begin shipping ore to the Bonne Terre mill and thus make the ninth producer out of a total of 15 shafts.

The Doe Run Lead Company, closely affiliated with the St. Joseph Lead Company, had a prosperous year and materially increased its output. The new 2000-ton concentrator (No. 3) at Flat River started in March, and was successfully operated on ore from the Mitchell shaft and part of the output of the Flat River shafts. It is a thoroughly modern plant that is divided into four units housed in a steel building with concrete floors. The old or No. 1 mill at Doe Run, of 1500 tons capacity, and the No. 2, or old remodeled Columbia mill, of 600 tons capacity, were also operated, and the three mills were run on the output of six shafts.

The No. 6 shaft at Elvins, after lying idle for several years, was completed and equipped with an electric hoisting plant. A new shaft (No. 9) is being sunk on the property purchased from the Union Lead Company, two miles east of Flat river, where the diamond drill disclosed an attractive orebody.

The Desloge Lead Company completed its new or No. 6 shaft near Leadwood and made regular ore shipments to its 1000-ton mill over a spur of the Desloge railroad. The mill at Desloge also received ore from the No. 3 shaft near the mill and from the No. 4 shaft on Big river, about one mile west of the mill. The No. 2 shaft, at the southern end of the property, was not operated. In the smelting department, the blast furnace and hand roasters were idle, but three Flintshire or air furnaces were run steadily. As they could smelt only a small portion of the concentrates, the surplus was shipped to the Federal smeltery at Alton, Ill.

The National Lead Company maintained its usual output. Its 1500-ton mill was supplied from four shafts and the concentrates were shipped to its large smeltery at Collinsville, Ill.

The year 1909 found the Federal Lead Company with its construction and readjustment work at last finished. Although the youngest of the St. Francois county producers, it has grown so rapidly and been developed so energetically that it was by far the largest producer in the district in 1909. The company paid much attention to increasing production and reducing cost. Results were more than satisfactory, and the output showed an unprecedented growth. In fact, the production of the company is today not only the largest in the district, but is probably the largest in the United States, if not in the world.

The Madison county mines, at the southern end of the disseminated-lead belt, all suffered from the great disadvantage of having much smaller orebodies than occur in St. Francois county. They therefore have smaller plants, and none of them reached an output as large as 3000 tons of lead in 1909. None of the companies operate smelting plants and the concentrates were sold in the St. Louis market.

The oldest lead mine in the United States, the Mine la Motte, which has been producing since 1720, had a quiet, uneventful year in 1909. The construction work of the present owners ceased with the completion of a 500-ton mill in 1908, and 1909 was devoted to production and the development of new orebodies. Part of the company's large acreage was leased on a royalty basis to two operating companies, each of which operated its own mill.

The North American Lead Company has for some time been a copper, nickel and cobalt producer, and the lead that is recovered as a by-product is a minor factor.

The Madison Lead and Land Company, formerly known as the Catherine, went into the hands of a receiver in the summer of 1909. As the company possesses a considerable acreage and as the mines, which are dry and shallow, have been operated less than 10 years, the property will probably be acquired by stronger interests and worked on a larger scale.

The Penicaut, Elizabeth, Manhattan and Bogy companies still remained in the drilling stage of development and did nothing in 1909. It is more likely that they will be absorbed by some of the present operators than developed into new producers.

New Mexico. (By Reinold V. Smith.)—The total lead output of the Territory in 1909 was 1275 tons as compared with 611 tons in 1908. The principal lead-mining districts are distributed for the most part in the central and southwestern parts of the Territory. Where the ores occur in limestone they carry silver, and where they occur as veins in the eruptives they usually also carry gold and copper. Mining was more active in 1909 than for several years past, the additional supply coming mainly from the increased production of lead-zinc ores of the southern counties. A significant development was the opening of two bodies, from 14 to 50 ft. thick, and carrying 12 to 16 per cent. lead carbonate, and zinc in considerable proportions, on the properties of the Boston Cerrillos Mining Company at Los Cerrillos. Some of the most prominent districts working were: Cook's Peak, where the American Smelting and Refining Company operated its mines under leases (the old dumps were hand-jigged to produce 40 per cent. concentrates); the Sandias mountains; the San Andres; Tres Hermanas; Lake Valley, and the Organ mountains, where development was pushed on several properties. The old Stephenson Bennett mine was in the hands of a receiver and was not operated.

Utah. (By Percy E. Barbour.)—The lead production of Utah in 1909 amounted to 65,975 tons, an increase of 21,980 tons over the output in 1908. Park City was the scene of several consolidations and of continuous expansion. The Silver King Coalition, including the original Silver King mine, which has already produced $20,000,000, is said to have blocked out in the mine $25,000,000, which is a better showing than at any previous time in its history. Over $12,000,000 have been paid in dividends. About 400 men were employed. The Ontario, which is credited with a still larger production, resumed shipments which are expected to return it soon to the dividend class. The Silver King Consolidated encountered good ore on both the 1550- and the 2050-ft. levels.

The Daly-Judge found a new orebody just below the 1400-ft. level, carload shipments from which averaged 23 per cent. lead, 29.3 oz. silver and 24 per cent. zinc. On the 1200-ft. level another orebody was discovered. These discoveries were in the territory which will be drained by the new tunnel from the Snake Creek side of the range. This tunnel is to be driven by the Snake Creek Mining and Tunneling Company, fathered by the Daly-Judge company. It will be of great benefit to all the other properties in the neighborhood, nearly all of which are in the enterprise. The tunnel will be about three miles long.

The American Flag took over the Constellation group and increased its equipment. It is considering the erection of a mill to recover the gold lost in concentrating the silver-lead ore. The Daly-West was forced to draw heavily on the ore reserves in the upper portions of the mine during the time the lower portions were drowned out owing to the cave in the Ontario drain tunnel. The mine is now looking well and the working force has been increased. The West Quincy and the Thompson companies arranged for a consolidation, the new company to be known as the Quincy-Thompson Consolidated.

Lead Mining in Foreign Countries.

Argentina.—In 1909 the owners of La Picasa mine, in the province of Mendoza, developed veins of galena, associated with pyrites in a quartz gangue, to the extent that they now consider themselves to be in a position to produce 30 tons of pig lead daily, or 9000 tons per year, which is believed to be about the amount of the consumption of lead products in the country.

Australia.—The production of pig-lead in Australia in 1909 decreased considerably, amounting to about 77,200 metric tons, as compared with 119,009 tons in 1908. The great bulk of the output, as in previous years, was derived from Broken Hill, New South Wales. Statistics of the production of this State for a period of years are given in the accompanying table.

LEAD PRODUCTION OF NEW SOUTH WALES. (*a*)
(In tons of 2240 lb.)

Lead.	1903	1904	1905	1906	1907	1908	1909
Base bullion	92,293	106,038	93,182	79,925	79,870	103,371	64,821
In ore exported	29,706	59,507	69,044	58,683	111,830	69,501	90,307
Totals..........	121,999	165,545	162,226	138,608	191,700	172,872	155,128

(*a*) According to the official statistics of New South Wales.

The very noticeable decrease in the production of the Broken Hill district was due to the miners' strike, which closed down many of the mines. At the Proprietary mine, hitherto the largest producer in Australia, underground operations were not resumed on the termination of the strike, and consequently no output of ore was contributed during the year. The total ore raised in the State was 417,217 tons less than in 1908. In Queensland 5240 long tons of lead ore, valued at £68,543, were produced in 1909.

Burma. (By T. D. La Touche.)—The existence of rich ores of silver and lead in the northern Shan States have been known for many years. Within the last few years interest in the mines has been revived by the discovery that the Chinese worked them principally for the sake of the silver contained in the ore, and threw away the bulk of the lead in the form of slag, huge heaps of which now mark the sites of their smelting furnaces. A company has been formed with the object of collecting and smelting this slag, and has been engaged in constructing a tramway from Manhpwi, the nearest station on the Northern Shan States railway, to the site, in order to bring away the material and smelt it at some more convenient spot. Up to the present time the company has confined its attention to the slags lying on the surface, but it should not be forgotten that, below the water level, there may still remain bodies of ore untouched by the Chinese miners, and it is to be hoped that as soon as the present scheme is in working order the ground will be thoroughly prospected with modern appliances.

Canada. (By John McLeish.)—The total production of 1909 of pig and manufactured lead and lead contained in base bullion exported was 45,857,424 lb. It is possible that there was also some lead ore or lead concentrates exported, of which no record has yet been received. Customs-department statistics indicate such an export of upward of 2,000,000 lb. The production of refined lead, and lead contained in base bullion exported in 1908, was 37,666,066 lb. Customs-department statistics in this year also indicate an export of lead ore or concentrates, and the total production in 1908 of lead available for consumption was estimated at 40,891,448 lb., an increased production in 1909 is, therefore, shown of from 5,000,000 to 7,000,000 lb. This production in both years was all from the province of British Columbia. The total amount of bounty paid during the 12 months ending December 31, 1909, on account of lead production was $346,528. The exports of lead in ore, concentrates, base bullion, etc., during the year were 3116 tons and of pig lead 5650 tons, or a total of 8766 tons. From 14,000 tons to 15,000 tons of domestic production were, therefore, available for home consumption.

(By E. Jacobs.)—The stimulating effect of the bounty paid by the Canadian government on lead produced in the Dominion is shown by the statistics. Production for 1903, the year immediately preceding the granting of the bounty, had fallen to 18,089,000 lb., but since 1904 it was not lower than 43,000,000 lb. in any year, while it rose to 56,580,000 lb. in 1905. The bounty is determined by the price of lead in London, it being on a sliding scale to insure to the Canadian producer a minimum price of £17 per ton. The maximum bounty is 75c. per 100 lb. of lead, payable when the London quotation is £14 10s. or lower.

East Kootenay produced more than half the lead mined in British Columbia. Its total for 1909 was less by between 3,000,000 and 4,000,000 lb. than that of 1908, partly owing to a suspension of production at the Sullivan Group mine (this mine later resumed work), and partly to a decreased output of this metal from the St. Eugene and North Star mines. The output of mines in the Ainsworth mining division was over 10,000,000 lb., being double that of 1908. More than half of this increase was made by the Blue Bell mine, with a production of about 6,466,000 lb. in 1909 as against 2,600,000 lb. in 1908. The Whitewater and Whitewater Deep mines produced about 3,355,000 lb. as compared with 2,000,000 in the preceding year. The Cork mine, on the south fork of Kaslo creek, also contributed to this increase, though in much smaller degree.

The production of Slocan mines fell off approximately 750,000 lb., the chief losers being the Rambler-Cariboo and Standard mines. Richmond-Eureka and Van Roi both considerably increased their output, the former producing 1,357,000 lb. and the latter 1,788,000 lb. of lead.

In the Nelson division, the Yankee Girl, at Ymir, was a new producer, with between 300,000 and 400,000 lb. to its credit. The Iron Mountain Company's Emerald mine, near Salmo, advanced its production from about 400,000 lb. in 1908 to 764,000 lb. in 1909. The La Plata, on Kokanee creek, near Nelson, was idle all the year.

The Consolidated Mining and Smelting Company of Canada, Ltd., during 1909 increased the lead-smelting capacity of its works at Trail and also enlarged its electrolytic lead refinery.

China. (By T. T. Read.)—Small amounts of lead bullion come out of southwest China, down the Yangtze river, about 300 tons having passed through Ichang in 1909. Lead ores also come from Hengchou and Yang-chou prefectures in Hunan province, amounting to about 1500 tons in 1908. The larger part of this is exported to Belgium and Great Britain, but an appreciable fraction is smelted at the reduction works owned by Carlowitz & Co. at Wuchang. In 1908 exports of lead ore amounted to 1283 metric tons. Imports of pig lead for the same year were 10,707 metric tons.

Germany.—In 1909 the production of pig and hard lead in Germany amounted to 167,920 metric tons, as compared with 164,079 tons in 1908. Of the total production the State of Bonn contributed 105,978 tons; Breslau, 37,360 tons, and other Prussian States 9824 tons, making a total for Prussia of 153,162 tons. Other German States supplied 14,758 tons. The two silver-lead reduction works in Upper Silesia had nine blast furnaces, five reverberatory, nine roasting, four cupeling and two silver refining furnaces in operation. They produced 37,360 tons of lead, and 2295 tons of litharge. The mines of the district produced 58,568 tons of lead ore. The accompanying table shows the German imports and exports of lead ore and metal for a series of years.

GERMAN IMPORTS AND EXPORTS OF LEAD.
(In metric tons.)

Year.	Metal.						Ore.					
	1904	1905	1906	1907	1908	1909	1904	1905	1906	1907	1908	1909
Imports.....	61,388	78,528	71,040	75,200	77,649	77,293	83,807	92,667	89,979	137,861	133,597	111,017
Exports.....	23,169	32,515	27,039	38,259	40,568	42,692	1,312	1,496	1,916	1,296	1,189	2,556

Great Britain.—The production of lead ore in Great Britain in 1908 amounted to 29,249 long tons, valued at £259,408 at the mines and containing 20,908 tons of available lead, which, according to the mean monthly prices of lead in the London market for the year would be worth £288,124. The most productive mines at the present time are situated at Mill Close in Derbyshire, Rhosesmor and North Hendre in Flintshire, Leadhills in Lanarkshire, Queensberry in Dumfriesshire, Greenside in Westmoreland and Foxdale in the Isle of Man. The lead ore, which is almost entirely an argentiferous galena, occurs in veins in sedimentary rocks, especially in those of the Carboniferous epoch. The deposit at Foxdale, however, is an instance of a highly productive lead vein in granite. The domestic supply of lead is not sufficient to satisfy the demand, and large quantities are imported. In 1908 these imports amounted to 23,484 tons of lead ore and 237,508 tons of pig and sheet lead, which together are estimated as the equivalent of 256,295 tons of metal. The exports for 1908 were 13,263 tons of lead ore and 41,864 tons of pig and sheet lead, which together are reckoned as the equivalent of 69,994 tons of lead. The metal available for domestic consumption was, therefore, 207,300 long tons.

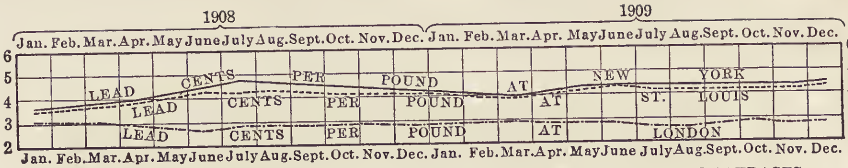
Greece.—In 1909 the production of lead in Greece amounted to approximately 15,300 metric tons. In the manufacture of pig lead at the Laurium mines results were much better than in the previous year, i.e., the yield was greater, percentage of silver higher, and cost per ton less. Mining was carried on more economically and improvement made in processes for washing ore and manufacture of briquets. Cheaper smelting is ascribed to better yields, reduced railway tariffs and more careful maintenance of the plant. Receipts in 1909 were $47,092 more than in 1908, the losses of the latter year being thus transformed into a profit of $13,510. The market, however, was very poor, and on account of low prices, combined with unfavorable rates of exchange, mining of lead ores was slightly curtailed.

Mexico.—The total lead production of the country in 1909 was approximately 118,000 metric tons. The main output came from the Central Plateau country, where the great camps of Sierra Mojada, Almaloya, Niaca and Santa Eualalia are situated. Here the lead ores occur mostly as carbonates. The lead production from the numerous mines in the northeastern States of the republic continued large, and was from widely distributed camps. This ore was mostly shipped to the smelteries at Monterey. Most of the lead ores in Mexico carry silver and are available for this reason. The lead, as bullion, is mostly shipped to the United States for refining.

Spain.—In 1908 the production of non-argentiferous lead ore in Spain amounted to 126,676 metric tons, and of silver-lead ore to 165,382 metric tons. The smelteries of the kingdom produced 134,321 metric tons of clean lead, and 53,741 tons of argentiferous lead. The new railroad from Linares to the city of La Carolina, which was opened for traffic on Nov. 14, 1909, will be an important aid to the lead mining industry of the country.

The Lead Markets in 1909.

New York.—The general business revival which followed after the so-called "Taft boom" extended only a few days into the year 1909, and lead, like all other metals, was affected by the reaction which followed during the latter part of January and lasted until well into spring. After selling early in January at 4.20c. New York, prices receded and the decline was not checked until the market had dropped below 4c. During the month of March, the demand for the spring requirements of the lead-consuming trades began to make itself felt and prices began to harden. A buying movement set in, in which all interests participated, and in consequence the price was carried up to 4.35c. New York, late in May. From that time on the market displayed a



COURSE OF LEAD PRICES IN 1908 AND 1909, PLOTTED FROM THE MONTHLY AVERAGES

strong undertone, the consumption for all purposes being on a very satisfactory scale. The requirements for lead-covered cables, which had been at a low ebb since the panic of 1907, at last began to make an impression upon the stocks carried over from that period. It was due to their existence and slow distribution that the improvement in prices did not make headway more quickly. As the year drew to a close, this burden was reduced to a normal point. On the other hand, the demand from all sources improved at a rapid rate, and under the impetus of a large business, prices during December advanced quickly to 4.70c. New York, at which figure the market closed firm and active.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1897....	3.04	3.28	3.41	3.32	3.26	3.33	3.72	3.84	4.30	4.00	2.96	3.70	3.58
1898....	3.65	3.71	3.72	3.63	3.64	3.82	3.95	4.00	3.99	3.78	3.76	3.76	3.78
1899....	4.18	4.49	4.37	4.31	4.44	4.43	4.52	4.57	4.58	4.58	3.70	4.64	4.47
1900....	4.68	4.68	4.68	4.68	4.18	3.90	4.03	4.25	4.35	4.35	4.58	4.35	4.37
1901....	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.15	4.33
1902....	4.00	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.069
1903....	4.075	4.075	4.442	4.567	4.325	4.210	4.075	4.075	4.243	4.375	4.218	4.162	4.237
1904....	4.347	4.375	4.475	4.475	4.423	4.196	4.192	4.111	4.200	4.200	4.200	4.600	4.309
1905....	4.552	4.450	4.470	4.500	4.500	4.500	4.524	4.665	4.850	4.850	5.200	5.422	4.707
1906....	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907....	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908....	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.2
1909....	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273

London.—The market opened firm, with a high premium paid for forward delivery, due to the strike at the Broken Hill Proprietary mine, which threatened to cut off supplies from that important quarter. In January up to £13⅞ was paid for April delivery, while prompt delivery could be had at £13⅜, the market closing at the latter figure. In February there was a slightly improved demand due to speculative purchases. The market developed considerable activity toward the close, when foreign brands commanded £13½, and English £13¾@13⅜ per ton. March was uneventful and prices remained practically unchanged. In April the market started at £13¾ for foreign brands, but gradually declined to £13¼, and it was not until the latter part of the month that signs of recovery were manifest. The closing value of English brands was £13½. May opened with a depressed market and a decline in price, but during the middle of the month a considerable demand developed from consumers and for export, and the price rose again to £13½ for English brands. The summer months were uneventful and prices gradually declined. The closing values of English brands in June, July and August were: £13, £12⅞ and £12¾ respectively. In September the demand improved slightly, and at the end of the month foreign and English brands commanded £13¼ and £13⅜. October opened with brisk inquiry and prices advanced, until on Oct. 18, foreign brands were quoted as high as £13⅜ per ton. Prices gradually eased and closed at £13@13⅛ for foreign brands, and £13⅛@13⅜ for English. During November the market remained steady and closed at the same prices as in October. In December buying was restrained by the approaching end of the year and the reduced demand incidental to the season, but the market closed steady and with no marked decline in prices.

AVERAGE MONTHLY PRICE PER 2240 lb. OF LEAD AT LONDON. (a)
(In pounds sterling.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897......	11.717	11.708	11.562	11.787	11.837	11.912	12.250	12.679	13.650	13.575	13.100	12.600	12.367
1898......	12.508	12.362	12.650	13.062	13.700	13.437	12.950	12.800	12.800	13.050	13.412	13.100	12.983
1899......	13.375	14.350	14.150	14.375	14.146	14.283	14.385	14.733	15.267	16.179	17.096	16.883	14.933
1900......	16.296	16.542	16.612	16.733	16.900	17.225	17.533	17.633	17.667	17.596	17.229	16.233	16.987
1901......	15.925	14.667	13.379	12.421	12.275	12.342	12.150	11.692	11.954	11.600	11.267	10.533	12.521
1902......	10.567	11.617	11.508	11.596	11.600	11.271	11.233	11.121	10.892	10.746	10.717	10.754	11.262
1903......	11.304	11.708	13.225	12.404	11.800	11.437	11.383	11.146	11.167	11.108	11.108	11.179	11.579
1904......	11.558	11.592	12.037	12.254	11.754	11.521	11.667	11.737	11.787	12.187	12.892	12.775	11.983
1905......	12.875	12.462	12.296	12.658	12.762	13.000	13.608	13.958	13.950	14.679	15.337	17.050	13.719
1906......	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907.....	19.828	19.531	19.703	19.975	19.638	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908.....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909.....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042

(a) The statistics for 1897–1905 are from the report of the Metallgesellschaft, Frankfurt am Main. Those for subsequent years are from the *Engineering and Mining Journal*.

White Lead and Oxides in 1909.

The consumption of paints during 1909 showed an increase over 1908 fully commensurate with the growth of the country, and enough to indicate a revival of building operations in many sections where little new work was completed during 1908. The lead pigments enjoyed a full share of the increased demand, the beneficial effects of the agitation for paint legislation still being apparent in the growing use of pure white lead and linseed oil to the exclusion of their substitutes. Although but few new State laws were adopted the agitation of this subject was widespread. In this connection it is of interest that the committee of the Berlin Chamber of Commerce, appointed to discuss the inquiry of the Minister of Commerce and Industry as to the feasibility of finding an efficient substitute for white lead, reported that there is no such substitute for outside work, and that white lead in oil does not come in the category of poisonous substances that require special care in handling. The substitution of full net weights for gross weights or partial tare, was made complete in 1909 on pure lead in oil, and with its attendant advance in the price of small packages was accepted by the trade and consumers without creating any such serious protest as was predicted by the opponents of the "full weights and measures legislation" which led up to this change. The use of steel for packages of 100 lb. and under, was considerably extended during 1909, and promises to displace wood entirely, although the latter will continue to be used for the larger packages.

Lead Carbonate.—There was no change in the card price for lead in oil from Dec. 10, 1908, until Dec. 6, 1909, the nominal quotation being 6½@6¾c. per lb. for packages of 100 lb. or over. Active competition among corroders caused more or less irregularity in the actual price, however, so that a considerable portion of the year's business was probably done at a concession of about $5 per ton from these prices in spite of the fact that at no time was there any excessive supply in the hands of corroders. Owing to the high cost of linseed oil, lead in oil was advanced on Dec. 6 to 6¾@7c. per lb. for 100-lb. packages and over, and with a subsequent advance on pig lead there is some prospect at the close of a further rise in prices of all products before the spring trade opens.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES.

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
897	7,798	$744,709	105,804	$9,522,360	8,591	$773,190	477	$76,320
898	9,160	916,000	93,172	9,391,738	7,460	710,192	541	108,200
1899	10,199	1,070,895	103,466	10,812,197	10,020	1,032,060	928	139,200
1900	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	867	138,349
1903	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000
1904	13,938	1,672,569	126,336	13,896,913	12,487	1,248,691	1,125	168,681
1905	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
1906	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
1907	13 370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included in 1904-09.

Dry white lead was nominally 5⅜c. to large consumers, but with the bulk of the sales to carload buyers at 5¼c., a price that was really established by the large contracts entered into in the latter part of 1908, and which covered a good share of the consuming demand for 1909. The same course was followed this year, and a large tonnage placed for 1910 delivery at 5¼c., with an advance in the nominal quotation to

5½@5⅝c. per lb. on December 6. There was but little addition to the corroding capacity of the country during 1909, but 1910 will probably show a 10-per cent. increase.

The fact that in revising the tariff Congress reduced the duty on white lead to 2½c., without changing the rate on pig lead, leaves the margin of protection against foreign lead in oil so narrow that, unless metallic lead were to advance abroad with a consequent rise in the products corroders here would be unable to advance their prices much beyond the present limit, without opening the door to possible competition from abroad. At the present time English lead in oil could probably be laid down here, duty paid, at 6½c. per pound.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1896	1,543,262	$47,450	1,183,538	$52,400	51,050	$1,615	1,359,651	$51,077
1897	1,386,070	46,992	1,101,829	48,988	60,984	1,931	1,486,042	67,549
1898	682,449	25,780	506,739	24,334	56,417	2,021	795,116	37,745
1899	776,197	30,479	583,409	30,212	55,127	3,614	1,141,387	58,142
1900	549,551	25,532	456,872	28,336	77,314	2,852	1,068,793	61,885
1901	485,466	19,369	384,671	21,226	49,306	1,873	977,644	52,409
1902	1,075,839	37,833	506,423	25,320	88,115	2,908	997,494	49,060
1903	1,152,715	40,846	453,284	24,595	42,756	1,464	756,742	36,407
1904	836,077	30,115	587,383	33,788	44,541	1,500	766,469	37,178
1905	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
1906	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
1907	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909	760,179	30,428	694,599	39,963	90,655	3.740	496,231	27,562

Lead Oxides.—While the consumption of lead oxides was in excess of that of 1908 by reason of an increased demand for red lead for structural iron and steel work, and for litharge from the glass, rubber and other large consuming industries, prices were irregular and unprofitable to producers. Red lead sold as low as 6c. to carload buyers and litharge at 5½c., and even these figures were shaded early in the fall to work off stock which accumulated during the summer. At the close, however, there was a disposition to get back to a more reasonable basis, and the nominal advance on white lead extended also the oxides, with special concessions to the largest buyers much narrower than they were some month earlier. In a large way red lead was quoted at the end of 1909 at 6¼@6½c., and litharge at 5¾ and 6c. per pound.

Bibliography of Lead in 1909.

Betts, A. G. "Ueber die heutige Praxis der Elektrolytischen Bleiraffination." (*Metallurgie,* Apr. 21, 1909; 2½ pp.)

Betts, A. G. "Ueber die heutige Praxis der Elektrolytischen Bleiraffination." 1909; 1 p.)

Castek, Franz. "Die Bestimmung des Bleies in Erzen mit Hilfe der Schleudermaschine." (*Oest. Zeit. f. B. u. H.*, Oct. 30 and Nov. 6, 1909; 7 pp.)

Collins, Henry F. "Modern Silver-Lead Smelting at Laurium, Greece." (*Eng. and Min. Journ.*, May 1, 1909; 2¾ pp.)

Gherardi, G. "A proposito della determinasione del piombo nelle leghe di rame." (*Rassegna Mineraria*, July 1, 1909; 1 p.)

Guillaume, L. "Smelting Refractory Lead Ores at Laurium, Greece." (*Eng. and Min. Journ.*, Sept. 4, 1909; 2½ pp.)

Holley, C. D. "Manufacture and Properties of Mild Process White Lead." (*Journ.* Soc. Chem. Ind., Apr. 30, 1909; 1¾ pp.)

Hughes, L. F. "Sublimed White Lead." (*Journ.* Soc. Chem. Ind., Apr. 30, 1909; 1¼ pp.)

Keyes, C. R. "Ozark Lead and Zinc Deposits: Their Genesis, Localization and Migration." (*Bull.* A. I. M. E., Feb. and Oct., 1909; 45 pp.)

Lindgren, Waldemar. "The Tres Hermanas Mining District." (*Bull.* No. 380-C, U. S. Geol. Surv., 1909; 10 pp.)

Low, V. F. S. "Concentration of Silver-Lead Ores, Broken Hill." (*Aust. Min. Stand.*, Mar. 31, Apr. 7, 14 and 21, 1909; 17 pp.)

McNab, A. J. "Lead Smelting and Refining Practice at Trail, B. C." (*Bull.* Can. Min. Inst., also *Can. Min. Journ.*, July 15 and Aug. 15, 1909; 4½ pp.)

Michaelis, S. "Die Bleierzgange von Mahuida in Argentinieñ." (*Zeit. f. Prakt. Geol.*, Oct., 1909; 6½ pp.)

Poole, W. "Treatment of Broken Hill Ores." (Paper read before Sydney Univ. Eng. Soc., Nov. 11, 1909; 148 pp., in *Queensland Gov. Min. Journ.*, Jan., Feb. and Mar., 1909.)

Ruhl, Otto. "History of the Southeast Missouri Lead District." (*Min. World*, Apr. 17, 1909; 3¾ pp.)

Ruhl, Otto. "Typical Mining Practice in Southeast Missouri. (*Min. World*, May 29, 1909; 3¼ pp.)

Ruhl, Otto. "Milling Practice in the Southeast Missouri District." (*Min. World*, June 19, 1909; 5 pp.)

Sacher, J. F. "Die schnellste Bleibestimmung auf Nassem Wege." (*Chem. Zeit.*, Dec. 2, 1909; 1¾ pp.)

Sacher, J. F. "Zur Massanalytischer Bleibestimmung mit Kaliumpermanganat in alkalischer Lösung." (*Chem. Zeit.*, Dec. 18, 1909; 1 p.)

Staudt, J. S. "The Carter Process of White Lead Manufacture." (*Journ. Ind. and Eng. Chem.*, Nov., 1909; 3¼ pp.)

Thompson, G. W. "Dutch Process White Lead." (*Journ.* Soc. Chem. Ind., Apr. 30, 1909; 1¾ pp.)

Wilkie, John M. "The Colorimetric Determination of Lead in the Presence of Iron with Some Notes on the Preparation of Lead-Free Reagents by Co-precipitation with Ferric Hydroxide." (*Journ.* Soc. Chem. Ind., June 30, 1909; 3 pp.)

Williams, Gerard W. "Concentrating Difficult Lead Ores at Broken Hill." (*Eng. and Min. Journ.*, May 8, 1909; 2 pp.)

Wynne, J. B. "Flue Construction and the Saving of Flue Dust." (*Eng. and Min. Journ.*, Sept. 25, 1909; 2½ pp.)

Recent Improvements in Lead Smelting.

By H. C. Hoffmann.

Introductory—Physical Properties—Alloys.

New Publications.—L. S. Austin, "The Metallurgy of the Common Metals," *Mining and Scientific Press*, San Francisco, 1909. A second edition has been called for in two years and the 407 pages of the original edition have grown to 494 in the revised. The chapters on lead and desilverization of base bullion have been largely rewritten.

Properties of Lead.—Loutchinnsky[1] carried on a research in regard to the hardening properties of lead. For these experiments two kinds of lead were selected, one containing 0.05 per cent. impurity, mainly antimony, the other 0.3 per cent. antimony and copper. The method of measuring hardness was that of Brinnell. The results appear to show that placing lead under a heavy pressure destroys any irregularity of structure that the metal has assumed while solidifying from the liquid state or while undergoing mechanical treatment, such as rolling. The same author[2] has investigated the permeability of lead. The coefficient of magnetization of water being 0.79×10^{-6}, that of the lead which has solidified slowly from the molten state is 2.4×10^{-6}, and that of the lead which has been treated mechanically by hammering or drawing is 0.2×10^{-6}, or 12 times as small.

K. Mönkenmeyer[3] investigated the melting points of the halogens of lead, silver, thallium and copper and studied the constitutions of their alloys. The melting point of lead chloride is 495 deg. C., of bromide 370 deg. C. and of iodide 358 deg. C. Lead chloride and bromide form solid solutions. Lead chloride and iodide are slightly soluble in one another and form a eutectic mixture with 23 per cent. lead chloride, freezing at 306 deg. C. Lead bromide and iodide show a similar behavior, being only slightly soluble and forming a eutectic mixture with 51 per cent. bromide, freezing at 256 deg. C. In both cases under-cooling occurred in determining the cooling curves.

Lead Ores.

J. P. Rowe, in a general article[4] upon the Coeur d'Alene mining district, gives the data embodied in Table I concerning the lead and silver content of the ores mined, the ratio of concentration, and the assays of the concentrates produced.

---

[1] *Rev. de Métallurgie* (1909), VI, 545.
[2] *Ibid.* (1909), VI, 986.
[3] *N. Jahrbuch f. Mineral*, Beilageband, XII, 1; *Zeit. f. Krystallogr.* (1903), XLV, 609.
[4] *Min. World* (1909), XXX, 428.

TABLE I. COEUR D'ALENE LEAD-SILVER ORES.

Mine.	Pb %	Ag oz.	Concentration Ratio.	Concentrates.	
				Pb %	Ag Oz.
Bunker Hill and Sullivan	13.5	3.9	4 & 5 to 1	55	20
Gold Hunter	3 to 5	4	11 to 1	50	40
Hecla	9.2	5.8	5.5 to 1	50	30
Helena	9.2	5.8	5.5 to 1	47	28
Hercules	15	3 to 10	4 to 1	50	45
Last Chance	10	4	5 to 1	50	20
Morning	8	3	7 to 1	50	16
Standard-Mammoth	6	5	8.5 to 1	50	41

Smelting Practice.

Smelting in Utah—The United States Smeltery.—C. T. Rice gives a detailed description[1] of the smelting of the United States Smelting, Refining and Mining Company, at Bingham Junction. The leading features of the plant were discussed in these reviews[2] two years ago. The lead ores treated come mainly from Bingham Canyon and the Tintic district, Utah, and from Eureka, Nevada. Other ores are bought in the open market. The daily capacity of the plant is from 800 to 900 tons of ore, which is sampled in part at a custom sampling mill and in part at the smeltery. The sampling plant of the smeltery uses a Snyder mechanical sampler and has a capacity of 450 tons in 24 hours. Fine ores which are not blast-roasted are briquetted in a Chisholm-Boyd-White machine, which in eight hours makes from 30,000 to 36,000 briquets, 4 in. in diameter and 3 in. thick. The briquets are air-dried from three to eight days, according to the conditions of the weather. A description of the blast-roasting operation is given on page 490.

The smeltery has six blast furnaces 45x160 in. at the tuyere level. The charge, which is fed mechanically, is maintained at a hight of from 16 to 18 ft. The tops of the furnaces are closed by lever-operated doors. Three furnaces have A-shaped spreaders, while the other three have rails laid crosswise to the opening and parallel to the tracks on which the charge cars of four tons' capacity run. The charge is calculated to form a slag with SiO_2 37 per cent., FeO 27 per cent., CaO 21 per cent. and Zn 6 per cent. The slag assays 0.50 to 0.75 per cent. Pb. The capacity of the furnace in 24 hours is 200 tons charge exclusive of slag and coke. Slag and matte are tapped into a forehearth 4½x9x3½ ft. The overflow slag is collected in five-ton slag cars, which are run to the dump. The slag shells assaying 0.6 to 0.9 per cent. Pb are resmelted. The matte, so far collected in Rhodes molds, is to be tapped into Kilker matte cars

[1] *Mines and Methods* (1909), I, 5.
[2] *The Mineral Industry* (1907), XVI, 667.

(see page 493). It is roasted in hand-rabbled reverberatory furnaces. The bullion is tapped into buggies and then poured into one of three bullion kettles, to be drossed twice. The first dross is dry; the second, taken when the temperature of the lead has fallen, is wet or rich in lead, and is removed to a liquating furnace, whence the resulting dross goes back to the ore blast furnace. The clean bullion is cast into 450-lb. anodes, to be desilverized by the Betts electrolytic process at the company's refining plant at Grasselli, Indiana. The gases from the blast furnaces go direct to the baghouses, as do those from the roasting furnace after the sulphur trioxide and soluble corrosive metallic sulphate has been neutralized. The yield in lead is high (97 per cent.), and little silver and gold are lost. The handling of gases is discussed on page 495.

The Tintic Smeltery, Silver City.—According to L. A. Palmer,[1] this plant treats lead ores and sulphide ores carrying precious metals. The sampling department has two divisions—the sulphide mill, provided with Vezin apparatus, and the oxide mill, served by Taylor-Brunton machines. Roasting is carried on in two 15x60-ft. reverberatory furnaces. Fine ores and flue dust are roasted and sintered in a reverberatory fusing furnace. The gases from both furnaces, before they enter the stack, pass through a flue 12 ft. by 8 ft. 10 in. in cross-section, having the form of a catenary curve. There are four lead and one copper blast furnaces. The lead furnaces are 48x160 in. at the tuyeres, and the ratio of cross-section of the shaft at the throat to that of the crucibles is as 2½ to 1. A furnace has 10 water jackets, one on each end and four on a side. Each of the side jackets has two 4-in. tuyere openings 20 in. apart. The tuyeres are served by a 36-in. blast-main. The rectangular crucible of the blast furnace is enclosed by an elliptical brick wall tied by heavy iron rods. The lead is tapped from the well into the slag pots and wheeled to three 50-ton smelting kettles to be freed from dross before it is cast into 100-lb. bars. Slag and matte are tapped into 4x8½-ft. settlers, and the overflowing slag is collected in two-ton slag cars and hauled by locomotives to the dump. The slag shells on their way from the dump are discharged onto an 8-in. grizzly, beneath which is a self-dumping skip delivering to bins on the feed floor. The gases from the blast furnaces pass through 60-in. downcomers into a balloon flue, 10 ft. in diameter and 100 ft. long, provided with dust doors at intervals of 10 ft. The flue delivers through a 120-in. elbow into three dust chambers, each of which is 100 ft. long. It has a catenary cross-section 12 ft. 6 in. by 9 ft. 1 in, and is supplied with cleaning doors 10 ft. apart. The furnaces are run with 12.12 per cent. coke, coming from Sunnyside,

[1] *Mines and Minerals* (1909), XXIX, 537.

and a blast pressure of from 32 to 34 oz. The charges are calculated to form a slag with SiO_2 33.4 per cent., FeO 33 per cent. and CaO 24 per cent. The slag assays 0.7 per cent Pb and 0.7 oz. Ag per ton. The first matte contains 7 per cent. Pb, 6 per cent. Cu and 25 oz. Ag per ton.

Smelting in Montana—East Helena Works.—This works[1] treats mainly galena concentrates from the Coeur d'Alene district, Idaho. The ore is roasted in reverberatory furnaces and in a Huntington-Heberlein plant which at present has 12 converting pots, but is being enlarged. The baghouse for filtering blast-furnace gases was put in commission again about November, 1908. Formerly a bag 30 ft. long and 18 in. in diameter lasted eight or nine months. At present its life is about 18 months, a considerable difference considering that a bag costs from \$1.25 to \$1.50. Experiments toward lengthening the life of the bags by dipping them in linseed oil and wringing dry, or by saturating them with fireproofing material such as is used on theater curtains, have not given favorable results. In the Godfrey furnaces an addition of lime to the charge has permitted quicker roasting, and hence an increased tonnage. The baghouse dust, with about 40 per cent. As and 40 per cent. Pb, is burnt on the floor of the house, where some of the arsenic escapes into the open. The residue is then added to the ore charge. The base bullion produced contains 0.5 per cent. arsenic.

Smelting in British Columbia.—A. J. McNab describes the lead smelting and refining works at Trail.[2] The plant was built in 1896 for the treatment of gold-copper ores, and has undergone many changes. At present it is the only lead smeltery in British Columbia. It has a Huntington-Heberlein blast-roasting department, with eight Huntington-Heberlein mechanical roasters and 24 pots; a smelting department with two blast furnaces, treating together 320 tons of ore per day, and a third in process of erection intended to smelt from 240 to 250 tons; and a refinery department treating daily 75 tons of lead bullion by the Betts process. Of the ore treated, 80 per cent. is a galena concentrate with from 45 to 75 per cent. Pb, 10 per cent. is oxide lead ore and the rest is dry gold and silver ore, with some concentrate from gold stamp mills.

Lead ores are sampled by Vezin machines, and concentrates by fractional selection. The ores are bedded in large flat bins holding from 600 to 700 tons. The bedded mixture averages 50 per cent. lead. The charge for the mechanical roasters serving the Huntington-Heberlein pots averages Pb 40 to 44 per cent., Fe 10 to 13 per cent., SIO_2 8 to 11 per cent., CaO 7 to 10 per cent., and Zn under 10 per cent. Experi-

---

[1] *Eng. and Min. Journ.* (1908), LXXXVII, 350.
[2] *Journ.*, Can. Min. Inst. (1909), XII, 424; *Can. Min. Journ.* (1909), XXX, 438, 498; *Min. World* (1909), XXXI, 511.

ence has shown that charges with over 45 per cent. Pb do not work satisfactorily. There has been no occasion to run any length of time on charges containing less than 38 per cent. Pb, and it is believed that charges with 38 to 40 per cent. Pb would give the most desirable kind of a clinker. As to the relation of SiO_2 and Fe in the charge, the Fe ought to be at least equal to the SiO_2, and preferably 1 or 2 per cent. higher. In running with SiO_2 from 2 to 4 per cent. higher than Fe, there has always been trouble, in that in the blast furnace the tonnage fell off, the heat crept up and the lead content of the slag increased, although the sulphur content of the blast-roasted material was lower than normal. The explanation furnished is that the blast-roasted material was too readily fusible and became liquefied nearer the throat of the furnace than was desirable. The suggestion occurs to the reviewer that the scorification was carried too far in the pot, furnishing an extremely dense slag readily fusible and difficult of reduction, instead of porous sinter having the opposite properties.

As to the lime in the charge, the results have been unsatisfactory if the amount fell below 7 per cent. As a rule, a mixture contains from 8 to 9 per cent. However, less than 7 per cent. lime would work, if the iron could be correspondingly increased while the lead content was held at 42 per cent.; but roasted charges low in lime are tough and difficult to break by sledging. There has been no occasion to increase the lime to above 10 per cent. The charge for the mechanical roaster is made up of bedded ore, limestone, stamp-mill concentrates and blast-furnace matte (high in Pb, and low in Cu). It is put through a cylindrical mixer, which discharges into the boot of an elevator delivering to chutes which convey the material to the hoppers of the mechanical roasters. One cylinder serves four roasters. The Huntington-Heberlein mechanical roaster is practically the same as the Godfrey. The hearth is 26 ft. in diameter and makes one revolution in three minutes. The fire box is 6x3 ft. The mixture, fed at the center and containing from 14 to 17 per cent. S, passes through the furnace in two hours and retains 8 to 8.5 per cent. S. The limit in sulphur for the pots is 9 per cent. The capacity of the roaster is 38 to 45 tons in 24 hours. The roasted ore should consist of small, sintered globules which show no components of the original charge. The ore, while being discharged opposite the fire box, drops through a spray of water into a brick bin. Enough water is suppied for the cooled roast to retain 5 per cent. of it. From the bin the material is brought in cars to the tops of the converters.

The converters are 8 ft. $8\frac{1}{2}$ in. in diameter and hold a charge of 10 tons of mixture. The cast-iron grating is in four sections, which are bolted together. Steel proved a failure, as the heat caused it to buckle. In operating, a few slabs of wood are charged with a shovelful of glowing coals, and a small blast is turned on and kept going until the fire burns freely, when a charge of ore is dropped from the hopper and leveled. The blast is now quickly increased to the extent of six to eight ounces and then gradually reduced, so that when the fire appears at the surface, i.e., after about eight hours, the pressure has fallen to two ounces. Instead of starting a pot with slabs of wood, a hot charge from the roasting furnace may be used as a primer. The blown charge is dumped onto a cast-iron cone, and the broken cake crushed in a 20x20-in. Blake crusher set to furnish material passing a 6-in. ring. Some metallic lead is always found in the blown charge. At the works low-grade copper matte (Cu 15 per cent., Fe 56 per cent., S 27 per cent.) is rough-roasted in an O'Hara or Godfrey furnace and then blown in the converter without the addition of any lime, reducing the sulphur to from 1 to 3 per cent. Lead matte with up to 25 per cent. Pb is similarly treated.

The smelting department has one blast furnace, 45x140 in., treating 150 tons of ore (not charge) per day; another, 45x160 in., treating 170 tons per day; and a third, 45x215 in., with an estimated daily capacity of 240 to 250 tons. The smaller furnace has seven and the larger furnace eight 4-in. tuyeres on a side. The distance between tuyeres is 20 in. In the new furnace the tuyeres are 15 in. apart. The hight of the smelting column is 17½ ft. and the blast pressure is 32 oz. The charge averages 85 per cent. Huntington-Heberlein material and never contains less than 75 per cent. of it. The lead content of the charge, exclusive of slag, is usually 40 per cent., but with low sulphur even 45 per cent. has given good results. With from 40 to 45 per cent. lead in the charge the sulphur content should not exceed 4 per cent., otherwise the slag gets mushy. Three per cent. sulphur is a good figure. A difference of 2 per cent. in the matte produced will make a variation of from 10 to 20 tons in the amount of ore smelted. From 30 to 40 per cent. of the sulphur in the charge is eliminated in the smelting owing to the reactions between sulphide, sulphate, and oxide. The slag aimed at contains SiO_2 31 to 33 per cent., (FeMn) O 24 to 30 per cent., and CaO 18 to 20 per cent. Going lower than 31 per cent. SiO_2 does not increase the speed of the furnace and going above 33 per cent. retards it. Variations in FeO within the limits given have little effect upon the result. Raising the lime content to above 20 per cent. makes the breast hard. With a high percentage of sulphur, the lime in the slag has to be reduced to 17 to 18 per cent., as the slag otherwise becomes mushy. The lime also has to be reduced if the zinc content rises above 12 per cent. The usual zinc content is from 7 to 12 per cent. Alumina averages 11 per cent. and covers a range of from 8 to 16 per cent. Its presence in quantities of from 13 to 16 per cent. makes the slag heavy and less fluid and decreases the smelting power of the furnace. The waste slag averages 1 per cent. Pb and 0.4 oz. Ag.

In fluxing, an addition of from 1 to 1.5 per cent. scrap iron assists in keeping lead out of the slag. Slow running (125 tons ore per day) gives cleaner slags than quick running (160 tons ore per day). A high-sulphur charge decreases the smelting power and increases the lead content of the slag. A furnace campaign lasts from six to seven months. By that time the wall accretions have reduced the throat area to such an extent as to cause the heat to creep up and to create loss of lead by volatilization. A furnace produces about 70 tons of lead bullion in 24 hours. The lead runs continuously from the lead well into one of two 3-ton cooling kettles where it is drossed and cast into 90-pound bars. An average of a month's product showed: Pb 98.5, Cu 0.22, Fe trace, Mn none, Zn 0.098, Sb 0.32, As 0.28, Ni none, Co none, Cd none, Bi 0.0133 per cent., Ag 100 oz., Au 1 oz.

The Betts Refining Plant.—The lead bullion is melted down in 50-ton steel kettles and pumped by a submerged $1\frac{1}{2}$-in. centrifugal cast-iron pump driven by a 2-h.p. electric motor, into a receiver from which pipes, provided with plug valves, lead to 10 vertical steel anode molds immersed in water. Each mold has a movable head by means of which the anode is lifted from it and placed on a car by a crane. The head is then freed by a blow from a hammer and returned to the mold. A car holds 10 anodes. The anodes from two cars are placed together and transferred by an electric crane into an electrolyzing tank. The cathode lead is melted down in the same manner as the lead bullion. A centrifugal pump delivers the molten metal to a receiver from which 100-℔ bars are cast from a swinging pipe into molds placed in a semicircle. Lead for the Chinese trade is cast in 180-℔ pigs. The cathode starting sheets are also cast in the same building. An iron trough, of greater capacity than required for a starting sheet and hinged on the side, is filled with lead, then turned over to discharge its contents onto a cast-iron plate having a steeled surface and set at an angle of 1.8 in. to the foot. The necessary lead chills on the plate while the excess overflows. The sheets are removed from the plate, trimmed if necessary, transferred to a car, straightened, bent over at one end, and hung on a copper suspension bar $\frac{1}{2}$x$\frac{3}{4}$ in. in cross-section.

The tank room contains 24 tanks, 3x8x$3\frac{1}{2}$ ft., made of 4-in. fir and lined with asphalt. There are six rows of double tanks running the length of the building. The launders delivering electrolyte from the cascades into the central sump tank are situated to the right of the row of tanks. On one side of the launders is a cascade nine tanks long and on the other are two cascades five and six tanks long respectively. The solution enters a tank 7 in. from the bottom and overflows at the top. A tank holds 20 anodes set $4\frac{1}{8}$ in. apart and 21 cathodes. The latter are longer and wider than the former. The electrolyte prepared at the works contains 12 per cent SiF_6, 5 to 6 per cent. Pb, and has a specific gravity of 1.17 to 1.191. From $\frac{1}{2}$ to 1 ℔. of glue is added daily for each ton of lead to be deposited. The current density is 16 amp. per sq. ft. of cathode area and the total fall of potential in a tank is 0.32 volts. Anodes are exchanged every eight days leaving 15 per cent. scrap which is cleansed in water with brushes before remelting. An average analysis of market lead, representing a product of 2000 tons, gave As none, Bi none, Zn 0.0005, Ag 0.0013, Cu 0.00075, Fe 0.00075, Sn 0.0001, Sb 0.0028, Pb 99.9938 per cent. The anode mud is washed and the wash water evaporated until it has reached the concentration of the electrolyte. The washed slime is filter-pressed and assays Ag 35 per cent., Sb 25 per cent., As 20 per cent., Cu 8 per cent., and some Fe, Bi, Si, Te and Se. It is dried on trays which are run on cars into the furnace flue and is then melted in a water-jacketed reverberatory furnace lined with magnesia brick. The impurities are oxidized and doré silver 0.960 to 0.975 fine is produced. This is parted with sulphuric acid, the resulting silver being 0.999 and the gold 0.995 fine. The blue vitriol is 99.5 per cent. pure. Neither arsenic nor antimony is recovered. The author's new process for treating the slime is given on page 505.

Smelting in Mexico.—R. W. Perry describes[1] several small plants in Mexico which are of special interest at the present time when most operations are concentrated in large centrally located works. The lead smelteries discussed are those of Socavon and Linguna near Maconi, Queretaro.

Smelting at Laurium, Greece.—H. F. Collins discusses the present state of lead smelting at Laurium.[2] Another description of the works is furnished by Guillaume.[3] The following is a summary of both papers.

Analyses of ores and a description of the older practice by Collins have been reviewed in these pages.[4]

---

[1] *Eng. and Min. Journ.* (1909), LXXXVIII, 658.

[2] *Ibid.* (1909), LXXXVIII, 881.

[3] *Ann. des Mines* (Paris), (1909), XV, 5; *Eng. and Min. Journ.* (1909), LXXXVIII, 446.
The Mineral Industry (1904), XIII, 277; (1905), XVIII, 391.

The new blast furnace is 44x156 in. at the tuyeres, of which there are 10 on a side $4\frac{1}{2}$ in. in diameter, but provided with thimbles of $3\frac{1}{2}$-in. inner diameter. The working hight is 19 ft. 8 in. The jackets are high (7 ft.) in order to facilitate the removal of zinky wall accretions. There are eight on a side and one at each end. They are of soft steel (outside shell $\frac{5}{16}$ in. and inside shell $\frac{7}{16}$ in. thick) and have a water space of 4 in. The tuyere pipes, expanded against the orifices cut into the jackets, became leaky and have been made water-tight by welding with an oxy-acetylene blowpipe. The furnace, built by the Colorado Iron Works, has the usual features characteristic of the American type. The throat of the furnace is closed by a movable charging hood connected with a fixed sheet-iron flue. The hood has flap doors through which the charge is fed from side-dumping cars. The crucible casing of 25/64-in. steel is tamped with brasque. This is followed by a course of fire-brick and the latter by a course of chrome-magnesia brick composed of $\frac{3}{4}$ magnesia and $\frac{1}{4}$ chrome iron ore containing 50 per cent. Cr_2O_3. Speiss was found to attack ordinary fire-brick. The blast is supplied by two Roots blowers driven by 100-h.p. gas engines. Each delivers 10,500 cu.ft. of air against a pressure of from 35 to 40 oz. The forehearth, of 25/64-in. boiler-iron reinforced by I-beams, is $10\text{x}6\frac{1}{2}\text{x}4\frac{1}{2}$ ft. It is lined with one course of chrome-magnesia brick and has a capacity of 30 tons slag.

Slag and matte flow continuously into the forehearth through a water-cooled, bronze (98 per cent. copper) tapping jacket with an opening $2\frac{3}{4}$ in. in diameter and a water-cooled copper spout $7\frac{1}{2}$ ft. long. The flow of material is regulated by a water-cooled steel tube closed by a spherical head of copper serving as a stopper. This is held in glands hanging from fixed supports. The overflow slag leaves the forehearth by one of two water-cooled spouts, placed on opposite sides, and drops into cast-iron launders where it meets a stream of water and is granulated. The granulated slag is collected in sheet-iron hoppers of eight tons' capacity which collect slag and water, the water overflowing as the hopper is being filled. When full of slag, the water is drawn off through a valve. From three to five tons of matte and from seven to nine tons of speiss are tapped every 24 hours. The furnace has a lead well and two drossing pots each holding 660 lb. of lead. A charge weighs 10,560 lb. and contains 11 per cent. Pb. From 300 to 330 tons of charge are put through in 24 hours with 14 per cent. coke. There are eight men on the feed floor and four on the furnace floor. The yield in lead is 90 per cent. Analyses of the products are given in Table II.

TABLE II. ANALYSES OF LAURIUM FURNACE PRODUCTS.

	Lead Bullion	Speiss.	Shaft Accretions. A	Shaft Accretions. B	Slag
Pb	97.38	3.00	16.90	16.00	0.80
Bi	0.09	....	....	....	....
As	0.40	33.00	....	....	....
Sb	1.60	....	....	....	....
Cu	0.38	....	....	....	....
SiO_2	....	....	....	....	25.20
Fe	....	50.00	....	....	23.24
Al_2O_3	....	....	....	....	11.38
MnO	....	....	....	....	2.88
CaO	....	....	....	....	17.33
MgO	....	....	....	....	trace.
Zn	....	....	32.25	57.05	9.87
S	....	....	12.23	2.73	0.78
Ag	0.1500	0.0150	....	....	0.0010
Au	0.0004	....	....	....	....

TABLE III. SO_2 CONTENT OF THE GASES IN THE CARMICHAEL-BRADFORD AND HUNTINGTON-HEBERLEIN PROCESSES.

Carmichael-Bradford Process Mixture, 1 Conc. to 1 Slime.		Huntington-Heberlein Process. Ordinary Mixture.	
Time	SO_2	Time.	SO_2.
10.15 a.m.	Charged.	10.45 a. m.	Charged.
10.25 "	6.2 Per Cent.	11.00 "	1.1 Per Cent.
10.35 "	8.3 "	11.15 "	2.3 "
10.45 "	8.9 "	11.30 "	3.6 "
10.55 "	10.0 "	11.45 "	5.7 "
11.05 "	8.8 "	12.00 noon	7.4 "
11.15 "	10.4 "	12.15 p.m.	8.8 "
11.25 "	10.4 "	12.30 "	7.4 "
11.35 "	10.8 "	12.45 "	7.2 "
11.45 "	11.3 "	1.00 "	8.2 "
11.55 "	11.3 "	1.05 "	6.0 "
12.05 p.m.	10.5 "	1.30 "	6.5 "
12.15 "	10.0 "	1.45 "	6.0 "
12.25 "	8.8 "	2.00 "	5.3 "
12.35 "	6.2 "	2.15 "	4.1 "
12.45 "	3.3 "	2.30 "	3.0 "
12.55 "	2.3 "	2.45 "	2.8 "
1.05 "	1.7 "	3.00 "	3.1 '
	Average 8.2 "	3.15 "	2.5 "
		3.30 "	2.1 "
		3.50 "	Finished.
			Average 4.9 "

Concentration and Smelting in Australia.—W. Poole describes the treatment of Broken Hill ores.[1] The main features of the work at the smelting plant at Port Pirie have already been reviewed in these pages.[2] The present notes are therefore confined to new features.

Both the Huntington-Heberlein and the Carmichael-Bradford blast-roasting processes are in operation. In the former, a charge of galena concentrate with fine limestone, iron ore and silicious ore are passed through five Ropp straight-line, gas-fired, mechanical roasting furnaces in from 12 to 16 hours. At the Cockle Creek works Godfrey furnaces are in operation, and at the Zeehan and Chillagoe works Edwards roasters.

[1] *Bull.*, Sydney University Eng. Soc., Nov. 11, 1908.
[2] *The Mineral Industry* (1907), XVI, 670.

In the Carmichael-Bradford process the ground gypsum is heated on iron plates sufficiently to lose 50 per cent. of its combined water and then screened to remove lumps which are discarded, as they run high in silica. Galena concentrates or mixed concentrates and slimes are mixed in a pug-mill with partly dehydrated gypsum in the proportion of 3 to 1, with the addition of some water. The mixture is passed through a trommel to ball it into lumps, which are warmed to drive off excess water and are then ready for the converting pots where they are blast-roasted in from three to four hours. Table III gives the records of time and of quantity of SO_2 in the gases of the Carmichael-Bradford and the Huntington-Heberlein processes when treating the same class of ore.

A typical analysis of gas from the Carmichael-Bradford process gives SO_3 0.4 per cent., SO_2 8.5 per cent., CO_2 0.5 per cent. CO none, O 10.6 per cent. and N 80 per cent.

It is seen that the Carmichael-Bradford process requires two hours 50 min. and the Huntington-Heberlein process five hours and five min. to treat a charge, and that the SO_2 content of the gases is very much higher in the first process. In both methods the SO_2 content rises quickly, remains practically unchanged for a considerable part of the blow, and finally falls off gradually. The high percentage of SO_2 in the gases of the Carmichael-Bradford process in comparison with the small amount of SO_3 formed, shows that on the whole the temperature in the pot must be low. It is stated that the cost of the plant for the Carmichael-Bradford process is lower than that for the Huntington-Heberlein, that the cost of working is also lower if limestone and gypsum are to be had at the same price, and that the treatment of slimes is more satisfactory.

The author mentions a Kapp-Kunze process[1] (blast roasting in pots of a mixture of raw galena, cupriferous or not, broken to 2-in. cubes, with iron ore) in operation for the last four years at Zeehan, Tasmania, and at Chillagoe, Queensland, and a McMurtry-Rogers process (blast-roasting in pots of sulphide copper ore broken to 1-in. size and containing SiO_2 15 to 35 per cent. and S 15 to 25 per cent.) in operation at Wallaroo, South Australia. He discusses from the literature the Savelsberg[2] and Dwight-Lloyd[3] processes, and describes the heap-roasting of slimes at Broken Hill.[4] Table IV gives analyses of the raw materials and products of the roasting and smelting department.

---

[1] *Min. Sci.* (1909), LIX, 67.
[2] *The Mineral Industry* (1907), XVI, 675.
[3] *Ibid.* (1907), XVI, 380.
[4] *Ibid.* (1907), XVI, 670.

The blast furnaces are 212x62 in. and 120x60 in. at the tuyere level. The hight is 20 ft. 6 in., and the blast-pressure 30 to 35 oz. The charges contain 17 per cent. Pb and are compounded so as to make a slag with SiO_2 25, FeO 33, MnO 6, CaO 12, ZnO 13, Al_2O_3 6 and S 3 per cent. The slag contains 1.5 per cent. Pb. The coke consumption is 16 per cent. The yield in lead is 95 per cent. and in silver 98 per cent.

TABLE IV. ANALYSES OF PRODUCTS AT VARIOUS STAGES DURING ROASTING, SINTERING AND SMELTING.

Material.	Pb %	Ag Oz.	Au Oz.	Cu %	Insol. %	SiO_2 %	FeO %	MnO %
Raw concentrates	42.98	22.90	0.010	0.166	21.25	10.80	5.84	6.27
Silicious ore to roasters	8.49	17.40	0.015	0.110	71.00	57.60	9.32	8.66
Roasted material to converter	34.97	20.35	0.010	0.160	19.02	11.75	7.57	5.47
Roaster product	28.32	13.12	0.0075	0.150	15.35	10.10	7.38	3.11
Sintered product	35.92	21.70	0.0075	0.140	15.12	12.67	7.38	5.66
Converter flue dust	35.54	20.43	0.01	0.098	17.90	11.15	6.04	3.32
Smelter flue dust	32.10	9.50	0.001	....	26.50	....	8.10	1.80
Smeltery slag	1.73	0.59	....	....	....	26.9	26.2	7.9
Smeltery bullion	98.80	....	0.044	0.34	0.23*	....	....	....
Copper dross	80.40	31.60	.038	5.52	....	....	....	....
Ironstone	....	....	....	....	3.0	....	8.50	0.50
Limestone	....	....	....	....	2.0	....	....	....

Material.	CaO %	Al_2O_3. %	Zn. %	ZnO. %	Totals. %	S as Sulphide. %	S as Sulphate. %	S as $PbSO_4$ %	Pb as $PbSO_4$ %
Raw concentrates	1.60	4.30	11.05	....	13.12	....	....	....	....
Silicious ore to roaster	1.92	7.70	trace	....	0.35	....	....	....	....
Roasted material to converter	6.70	4.40	8.63	10.75	8.45	5.75	2.70	0.96	6.20
Roaster product	6.65	3.15	4.36	5.98	10.20	4.07	6.13	3.50	22.70
Sintered product	6.65	3.80	8.72	10.86	3.94	1.34	2.60	1.68	10.90
Converter flue dust	5.46	4.00	7.12	8.87	7.79	4.64	3.15	1.43	9.30
Smeltery flue dust	3.0	2.1	....	....	5.29	4.14	1.15	....	....
Smeltery slag	16.2	4.5	....	12.5	2.9	....	....	....	....
Smeltery bullion	....	....	.05	....	0.38	....	....	....	....
Copper dross	....	....	.86	....	6.24	....	....	....	....
Ironstone	....	....	....	....	....	....	....	....	....
Limestone	54.0	....	....	....	....	....	....	....	....

* Insoluble. As, Sb, etc.

The zinc desilverizing plant is at Port Pirie.[1] The desilverizing kettle holds 31 tons of softened lead which is derived from 38 tons of lead bullion. Characteristics are that the copper softening and antimony softening of the lead bullion are carried on in two furnaces and that gold is separated from the bulk of the silver by making separate gold crusts which undergo a treatment different from that of the silver crusts.

Smelting in Queensland.—G. W. Williams in treating of the mining industry of Queensland describes[2] the lead and copper smelteries of the Chillagoe Railways and Mines Company at Chillagoe. Table V gives the analyses of the ores treated.

[1] *The Mineral Industry* (1907), XVI, 671: (1908), XVII 605.
[2] *Eng. and Min. Journ.* (1909), LXXXVII 603.

TABLE V. COMPOSITION OF ORES TREATED AT CHILLAGOE SMELTERY.

Name.	Ag Oz.	Pb %	ZnO %	Cu %	FeO %	SiO_2 %	S %	Al_2O_3 %
Lady Jane sulphide	11.5	20.0	18.0	4.0	22.0	12.5	23.0	....
Girofla sulphide	5.7	17.5	9.0	2.0	32.0	0.0	20.0	....
Ruddigore	1.0	....	....	4.0	9.0	60.0	4.0	13.0
Consols (purchased)	23.5	30.5	19.2	0.25	19.3	6.0	23.5	....
Girofla oxidized	14.3	16.7	1.8	8.4	26.0	22.4	3.0	....
Girofla flux sulphide	6.2	7.5	7.0	1.0	37.5	12.0	19.2	....
Mungana oxidized	11.0	13.0	1.0	10.0	20.0	27.5	2.0	....
Queenslander	4.0	....	6.0	4.0	28.0	18.0	22.0	6.0

The ores are blast-roasted in Huntington-Heberlein pots before they go to the blast furnaces. Lady Jane and Girofla ores are mixed in the proportion of 2 to 1, and then crushed and rolled. One-half goes into two Edwards roasters and the other is mixed with the rough-roasted ore to form the charge for the pots. An Edwards roaster is 89x16 ft. outside. The hearth is 83x14 ft. and has a slope of 5 deg. The sides of the hearth are 10 in. high and the roof in the center is 17½ in. above the hearth floor. There are two rows of 20 rabbles driven from two 3-in. shafts at the rate of 1 r.p.m. Opposite each rabble is a port 9x10 in. A rabble arm is 3½ ft. long and has fine blades. The furnace is heated from one fire-box at the end and two in the middle. In 24 hours it treats from 30 to 50 tons of ore which loses about 15 per cent. in weight. Table VI gives the screen analysis and the elimination of the sulphur of the roasted ore.

TABLE VI. SCREEN ANALYSIS AND SULPHUR CONTENT OF ROASTED ORE AT CHILLAGOE SMELTERY.

Size of screen	½ in.	¼ in.	⅛ in.	20-mesh	20-mesh
Per cent. of ore over screen-size	15	12.3	7.5	22	43*
Per cent. of S in this size	14.1	12	11.4	10.9	6.?

* Under screen-size.

The roasted ore is wetted, mixed with raw ore and treated in 12 pots having a capacity of 10 tons each. A pot averages 2½ charges a day with a blast pressure of 20 oz. The pots are supported by trunnions and dump their charges onto the floor beneath. It is stated that as much as 70 per cent. of fines are made but this must be an error. An average analysis of blast-roasted sinter shows Ag 12 oz., Cu 4 per cent., Pb 20, SiO_2 15, FeO 27, CaO 1.2, ZnO 15 and S 4.5. The lead blast furnace is 40x160 in. at the tuyeres which are 4 in. in diameter and placed nine on a side. From the top of crucible to the feed floor is 18½ ft. The ⅝-in. steel water jackets extend eight feet above the tuyeres and have no bosh. In 24 hours 36 charges of three tons each are put through using 13.5 per cent. coke and producing 17 tons lead bullion (60 to 65 oz. Ag per ton), 8 tons lead-well dross, 20 to 25 tons matte (Pb 19, Cu 23, S 20, Fe 20, Zn 8 per cent. and Ag 16 oz.), and slag which averages SiO_2 25, FeO 35, CaO 12, ZnO 5 to 16, Pb 2, Cu 0.55, S 3 per cent. and Ag 0.5 oz. The recovery of lead is 85 to 89 per cent. "available lead" i.e., the lead in excess of the copper present.

Considerable leady material is added to the copper blast furnace which produces lead bullion and copper matte rich in lead. The latter is blown in a converter. No data are given about the loss of metal.

Smelting in the Northern Shan States, Burma.—T. D. La Touche and J. C. Brown describe[1] the silver-lead mines of Bawdwin, Northern Shan States. The paper contains some illustrations of primitive furnaces for smelting and cupelling.

Smelting in the Ore-Hearth.—R. B. Brinsmade describes[2] briefly the process of smelting in the ore-hearth as practised by the Galena Smelting and Manufacturing Company at Galena, Kansas. There are in operation four ore-hearths. A hearth is 5 ft. long and carries a cast-iron air jacket similar to the old Rossie hearth of New York. Two men in eight hours treat 7000 lb. of ore which is a mixture of galena, some oxide lead ore, and blende (from 2 to 10 per cent.). The ore mixture assays about 70 per cent. Pb. From 40 to 60 per cent. of the lead is recovered as metal in the hearth. The fuel used is coal. Lime is added to stiffen the charge. In starting, lead is melted down in the crucible by means of a wood and coal fire. The gray slag is smelted in a 36-in. circular water-jacketed blast furnace. The gases from the ore-hearths and from the blast furnace pass through 450 ft. of flue before they reach the fan when they are forced into the baghouse. The temperature of the gases in the baghouse is given as 32 deg. C.

O. H. Pieher patented[3] a method of treating argentiferous lead ores drawing the gases by means of a fan through a dust flue and a sufficient number of iron pipes until all the dust, which alone carries silver, has settled out, and then forcing the silver-free fume through a baghouse.

The late C. V. Petraeus communicated to the reviewer several years ago that he had smelted silver-bearing galena ore successfully by this method. The principle that the dust carries the silver and not the lead fume is borne out by the long-established fact that in a lead blast-furnace plant the deposit at the end of the dust chamber or at the foot of the stack is usually rich in lead and poor in silver.

---

[1] *Eng. and Min. Journ.* (1909), LXXXVIII, 530; *Min. Journ.* (1909), LXXXVI, 48.
[2] *Min. World* (1909), XXXI, 1029.
[3] U. S. Pat. No. 920,388, May 4, 1909; *Eng. and Min. Journ.* (1909), LXXXVIII, 256.

TABLE VII. IGNITION AND INCANDESCENCE TEMPERATURES IN DEGREES CENTIGRADE OF SOME METALLIC SULPHIDES WHEN HEATED IN AIR.

Material.	Pyrite.	Pyrrhotite.	FeS	Ni 73.3 S 26.7	Co 66.37 S 33.63	Co 70.20 S 29.80
Size of grains.........	I II III	I II III	II	I II III	I II III	I II III
First notice of SO_2....	325 405 472	430 525 590	535	700 802 880	574 684 859	514 751 1019
Incandescence........	533	595	626	....	....	850

Material.	Stibnite.	Molybdenite.	Cinnabar.	Chalcocite.	Bi 83.3 S 16.7	Mn 61.01 S 33.98 Fe 2.02	Argentite.	Blende.	Galena*	Millerite.
Size of grains.........	1 III	I III	I III	I III	I III	I III	I III	I III	I III	I III
First notice of SO_2....	290 430	240 508	338 420	430 679	500 626	355 700	605 875	647 810	554 847	513 616

Note: I=0.1 mm. II=0.1-0.2 mm., III over 0.2 mm. * In oxygen.

Roasting.—K. Friedrich[1] carried on some investigations as to the ignition temperatures of some of the leading metallic sulphides in oxygen and in air. Incidentally he noted the temperatures at which decrepitation and sintering occurred. Of the sulphides given in Table VII, blende, pyrite, pyrrhotite, galena and millerite decrepitated at very low temperatures, the gas given off reddening litmus paper. This happened with blende at 40 deg. C., with pyrite at 60 deg., with pyrrhotite at 80 deg., with galena at 90 deg., and with millerite also at 90 deg.; the other sulphides showed higher temperatures of decrepitation. As to sintering, ores that give off sulphur or that contain orpiment, realgar or stibnite show the phenomena of incipient fusion. Certain concentrations of nickel and sulphur sinter at a low temperature. The same is the case with molybdenite owing to the ready fusibility of the oxide formed in roasting. With galena the liberation of lead is the cause of sintering. The degree of sintering is also governed by the manner of heating. Slow heating causes galena to sinter more readily than a quick rise of temperature and a coarse grain sinters less readily than a fine. In Table VII the behavior with oxygen, given in the original has been omitted. For analyses of the different minerals and the prepared sulphides, as well as for the details of their behavior, the reader is referred to the paper.

Blast-Roasting.—An editorial[2] reviews briefly the evolution of blast-roasting with special reference to the theories that have been held as to the chemical reactions that take place in the process, and to the facts that recent experimental work in the laboratory has brought out.

[1] *Metallurgie* (1909), VI, 170.
[2] *Eng. and Min. Journ.* (1909), LXXXVII, 613

H. O. Hofman presented a paper[1] on some developments in blast-roasting to the International Congress of Applied Chemistry held in London. The blast-roasting apparatus is divided into the two classes, up-draft and down-draft. Among the former are given the practice of the Huntington-Heberlein, the Savelsberg, and the Kelley modes of treating lead-bearing and other sulphide ores as carried out in this country. The second class is taken up by the Dwight-Lloyd sintering machines, of which the three types, the drum, the straight-line, and the horizontal-table machines are developed. The work they have done so far is described and the paper concludes with a discussion on the general principles followed in their practical operation.

Blast-Roasting at the United States Smeltery, Bingham Junction, Utah.[2]—At this plant blast-roasting is carried on in 19 so-called "roasting boxes" and a 20th serves to keep ready a supply of primer. A roasting box consists of a hearth, 6 ft. square and 3 ft. deep, with a bottom of cast-iron plates perforated by ⅜-in. holes forming also the top of a wind box, with sides of brick, and with a hopper-shaped top of sufficient capacity to hold six tons of charge. At the back of a furnace is a door 12x18 in. to admit an electrically driven ram which pushes out roasted and clinkered coke through an opening at the front which is closed by a sliding door. The upper part of the latter has a slot, also closed by a slide, to furnish access to the charge for leveling and closing blow-holes. The ram, similar to the one used in discharging the coke from horizontal retort coking ovens, stands on an electric car which travels on a track back of the battery of 19 blast-roasters, and serves to discharge them. The 20th box furnishes the primer necessary for starting an ore charge. The primer mixture is made up of one part of impure blende concentrate, one part of bituminous coal and 1½ parts of coke screenings. An analysis of the concentrate showed the following constituents: Zn 30.4, Pb 6.8, Cu 1.6, Fe 12.7, S 31.7, SiO_2 7.6 per cent., Au 0.06 oz., and Ag 4.2 oz. The desired quantity is placed on the hearth, brought to a red heat, when the blast is shut off, and the hot primer removed to the ore roaster. The ore charge consists of 33 per cent. concentrates, 5 to 10 per cent. fluedust, and the rest fine ore. The compositions of the ores used are given in Table VIII.

The mixture aimed at contains S 19 per cent., SiO_2 28 per cent., Fe 18 per cent., Pb 13 per cent., Zn 6.5 per cent. The limit of coarseness of the individual particle is ½ in. The different ores are bedded; a bed

[1] *Min. Journ.* (1909), LXXXV, 728.
[2] C. T. Rice, *Mines and Methods* (1909), I, 6; Private communication by G. W. Heintz general manager.

TABLE VIII. COMPOSITION OF ROASTING-BOX MATERIAL AT THE UNITED STATES SMELTERY, BINGHAM JUNCTION, UTAH.

Material.	SiO_2 %	Fe %	CaO %	S %	Cu %	Pb %	Zn %
Richmond fines	7.0	32.0	7.5	0.8	0.1	4.0	5.0
Cent Eureka L fines	70.0	6.4	4.0	0.7	1.2	3.5	0.6
Cent Eureka O fines	71.6	6.1	3.4	0.5	1.8	0.5	0.9
Lead plant fluedust	20.0	17.0	6.0	4.5	1.0	19.0	3.0
Baghouse dust	....	....	....	8.0	....	43.0	6.3
U. S. Concentrates	4.6	19.4	2.0	33.7	1.0	19.1	4.8
U. S. Concentrates	4.0	23.3	2.0	34.2	0.8	17.9	11.6
U. S. Concentrates	5.2	22.2	2.0	34.0	1.0	20.6	14.6
U. S. Concentrates	4.4	25.2	2.0	33.5	1.0	18.9	9.7

is transferred to a Smith concrete mixer when about 10 per cent. water is added and the moistened mixture is then carried by a bucket elevator to a bin, whence it is trammed as needed to the hoppers of the blast roasters to be drawn on to the hearths. Before charging a roaster with ore, the grate is covered with a layer of limestone or silicious ore to a thickness of about 2 in., then follows the necessary primer, spread to a thickness of 1½ in., and lastly the charge of six tons which when spread out evenly makes a bed about 26 in. thick. The doors are now luted with clay and the blast with a pressure of about 1 oz. is turned on. The pressure is increased as the roast progresses until at the end, i.e., after from five to eight hours, it has reached about 9 oz. During the operation the temperature is kept as low as possible. The slide in the front door is raised at intervals to watch the progress of the blast-roasting and to close any blow-holes by poking them and covering them up.

When no more sulphurous fumes are given off, and the roast is finished, the sintered cake is pushed by the ram into a sheet-iron boat and sprayed with water to cool the mass and wash off fines. The boat is transferred by a traveling crane to a 24x36-in. Farrell breaker set to crush to 6 in., when the crushed material is hauled to the stock-bins. The 19 blast roasters treat about 320 tons per day. The elimination of sulphur from ore charges varies from 65 to 70 per cent.; that from matte charges averages only 57 per cent. The latter are therefore desulphurized in hand reverberatory furnaces. The loss in lead and silver in blast-roasting is about 4 per cent. The blast-roasting plant is served per shift by nine men, viz., one boss, one ram man, five pot men, and two men charging the ore to the bins and hopper. The cost of treatment per ton of ore is $1.25. There are six hand-rabbled reverberatory roasters treating 70 tons matte in 24 hours with three men to a furnace on a shift. The sulphurous gases contain 15 mg. SO_3 per cu.ft. at 0 deg. C.

W. Borchers [1] in reviewing the paper of H. O. Hofman and W. Mostowitsch[2] upon the behavior of calcium sulphate at elevated temperatures with some fluxes, makes the comment that in the Carmichael-Bradford process one has to deal not with the system $PbS+CaSO_4$, but with the three constituents of the charge $PbS+CaSO_4+SiO_2$, and that SiO_2 plays a prominent role is made evident by the above research.

Hofman and Mostowitsch have added a postscript[3] to the paper quoted above in which they give the results of a reinvestigation of the decomposition at an elevated temperature of ferric oxide in a current of dry air. Their first tests had shown that Fe_2O_3 was stable at 1500 deg. C. With another sample, freshly prepared, they found that a measurable dissociation took place at 1375 deg. C. This figure agrees with the results of P. T. Walden[4] who, working in an evacuated tube and measuring the pressures due to the liberation of oxygen with rises of temperature, concluded that Fe_2O_3 was stable at 1350 deg C. A.M.,[5] commenting upon the decomposition of $CaSO_4$ by heat alone which Hofman-Mostowitsch show takes place at 1400 deg. C. only with fusion, quotes O. Schott[6] who found that decomposition occurred at 1450 deg. C. but mentions no fusion; and also M. Glasenapp[7] who holds that gypsum fuses above 1400 deg. C. and that decomposition begins at 1000 deg. C.

The Huntington-Heberlein process as carried on at Chillagoe, Queensland, and at Trail is reviewed on pages 478, 479 and 487.

A. S. Dwight and R. L. Lloyd have patented[8] the various forms of their now well-known down-draft mechanical roasting machines.

F. D. Weeks patented[9] a down-draft blast-roasting apparatus similar to the Dwight-Lloyd horizontal table machine. The latter resembles a horizontal picking table, in which the ring-shaped table is replaced by herringbone grates. There is a stationary feed hopper and igniter. The table makes one revolution in 45 min. and the sinter is removed by means of a scraper and deflecting apron. In the Weeks machine, the circular table is stationary, while the feed hopper for ore, and with it the igniter, moves slowly over the table. The moving apparatus also carries the scraper which removes the sintered ore in front of the feed.

The Blast Furnace.—With the mechanical charging of lead and copper blast furnaces, new charging cars are being brought out by manu-

[1] *Métallurgie* (1909), VI, 256.
[2] *The Mineral Industry* (1908), XVII, 591.
[3] *Bull.*, A. I. M. E. (1909).
[4] *Journ.*, Am. Chem. Soc. (1908), XXX, 1350.
[5] *Tonindust. Zeit.* (1909), XXXIII, 899, 933.
[6] "Kalksilikate und Kalkaluminate in ihren Beziehungen zum Portlandzement." Thesis, Heidelberg (1906), 58.
[7] *Tonindust. Zeit.* (1908), XXXII, 1201.
U. S. Pat. Nos. 916,391 to 916,397 incl., March 23, 1909.
U S Pa N 916 903, March 3, 1909; *Eng. and Min. Journ.* (1909), LXXXVII, 1140.

facturers. The Atlas bottom-delivery electric charging car[1] manufactured by the Atlas Car and Manufacturing Company, Cleveland, Ohio, and provided with electrical equipment by the Westinghouse Electric and Manufacturing Company of Pittsburg, Penn., is a recent example.

L. S. Austin describes[2] with two drawings a blast-furnace tuyere which he constructed in 1900, and which greatly resembles the one recently brought out by the Traylor Engineering Company. The main point is that the upper arm of the usual cast-iron 45-deg. elbow carries a cast-iron pipe with spherical joint that is attached to the former by means of a link.

E. H. Messiter discusses[3] briefly the advantages of the ore-bedding system that he introduced at the works of the Cananea Consolidated Copper Company.

J. W. Tudor[4] referring to the Kilker matte-tapping car discussed by Havard describes with sketches a matte car that he used years ago. This car carried a number of molds of which the two at the ends were slotted on one side and the intermediate ones on two opposite sides. Matte received by a central mold overflows toward the end molds. The device is a reproduction in iron of the sand molds formerly common with copper reverberatory furnaces.

F. T. Havard[5] describes with illustrations the Kilker matte-tapping car already discussed in these reviews.[6] Another description is furnished by F. C. Perkins.[7]

C. F. Shelby[8] gives a description illustrated by photographs and drawings, of the side-tilting slag car used at the Cananea smelting works. The length of the car is 13 ft. 7 in., that of the wheel base 8 ft., and the cast-steel bowl is 9 ft. 10 in. long, 5 ft. 2 in. wide and 3 ft. 3½ in. deep.

R. Hutchinson[9] discusses the explosion phenomena that occur when matte-bearing slag is granulated. He quotes the fact that copper poured into a wet mold will float on the water while lead will explode and be scattered in all directions. He attributes this difference to diffusivity (velocity of temperature-change in a metal) which is the ratio between the thermal conductivity and the specific heat. The thermal conductivity of copper, with silver as 100, is 74, of iron 11.9, of lead 7.9, of slag about

[1] *Eng. and Min. Journ.* (1909), LXXXVII, 619.
[2] *Min. and Sci. Press* (1909), XCVIII, 392.
[3] *Ibid.* (1909), XCVIII, 361; *The Mineral Industry* (1907), XVI, 356.
[4] *Eng. and Min. Journ.* (1909), LXXXVIII, 128.
[5] *Ibid.* (1909) LXXXVII, 1294.
[6] *The Mineral Industry* (1908), XVII, 597.
[7] *Min. World* (1909), XXXI, 314.
[8] *Eng. and Min. Journ.* (1909), LXXXVII, 204.
[9] *Ibid.* (1909), LXXXVII, 1272.

0.18. The diffusivity calculated for copper gives 777, and for lead only 219. The practical deduction is that metals of low thermal conductivity may not be poured into wet molds, that metals with a high conductivity may be so poured only when the speed of pouring exceeds the diffusivity and finally that matte having a low conductivity may not be poured into a wet mold.

H. Earle describes[1] a method of calculating slags made in smelting lead or copper which resembles the one generally used when the limestone contains considerable amounts of silica and iron. The whole is reduced to formulated statements from which the necessary amounts of iron ore and limestone can be ascertained by interpolation.

Behavior of Barium Sulphate.—W. Mostowitsch[2] studied the behavior of barium sulphate, alone and with fluxes, when subjected to an elevated temperature. The pure salt gradually begins to give off SO_3 at 1510 deg. C.; it fuses at 1580 deg. C. and is thereby further but not wholly decomposed, the fused mass consisting of a mixture of BaO and $BaSO_4$. The presence of small amounts of impurities, e.g., a trace of iron, causes dissociation to begin at a lower temperature. In the presence of silica the decomposition of barium sulphate begins at 1000 deg. C. Mixtures made up to form sub- and singulo-silicates began to be compacted at 1400 deg. C., while sesqui-, bi-, and tri-silicate mixtures sintered at 1350 deg. C. and fused at 1400 deg. According to G. Stein[3] the singulo-silicate becomes glassy at 1600 deg. and liquid at 1900 deg. C. Iron oxide also decomposes barium sulphate with the formation of barium ferrite; $nBaSO_4+mFe_2O_3=nBaOmFe_2O_3+n(SO_2+O)$. The reaction begins at 1100 deg. C. and is not so energetic as with silica. The action of Fe_2O_3 increases with the amount used in a mixture and with the temperature. Thus $BaSO_4:2Fe_2O_3$ fuses at 1350 deg. C. to a liquid consisting of BaO and Fe_2O_3, while $BaSO_4:Fe_2O_3$ and $BaSO_4:3Fe_2O_3$ require a temperature of 1400 deg. C. for liquefaction and even then the decomposition of $BaSO_4$ is not complete. Experiments in the reduction of barium sulphate by means of carbon showed that barium suphide begins to form at 600 deg. C. and that the reaction $BaSO_4+2C=BaS+2CO_2$ is complete at 800 deg. C. At a higher temperature some CO is formed according to the reaction $BaSO_4+4C=BaS+4CO$. The reduction by means of CO begins at 650 deg., reaches 98 per cent. at 800 deg., 99.1 per cent. at 900 deg., and is complete at 1050 deg. C. The barium sulphide formed is stable at 1000 deg., but gives off some sulphur at 1200 deg. C.

[1] *Eng. and Min. Journ.* (1909), LXXXVII, 962.
[2] *Metallurgie* (1909), VI. 450; *Eng. and Min. Journ.* (1909), LXXXVIII, 601.
[3] *Zeit. anorg. Chem.* (1907), LV 159.

Treatment of Jamesonite.—G. P. Ives and I. D. Ossa[1] investigated the metallurgical treatment of an ore in which jamesonite, $2(PbFe)S + Sb_2S_3$, was the metal-bearing mineral. Two lots of ore were treated. The analysis of one showed SiO_2 66.5, FeO 6.02, CaO 0.7, Al_2O_3 5.33, S 4.1, Sb 4.2, Pb 7.95, Zn 1.5, As 0.3 per cent. and that of the other SiO_2 35, FeO 3.85, Al_2O_3 1.3, S 9, Sb 17.5, Pb 32 per cent. The ore was roasted with free access of air, first at 350 deg. C., then at 700 to 900 deg. C. in order to sinter the oxide formed. The roasted ore was smelted in the blast furnace and gave lead bullion (Pb 78.8 per cent., Sb 16 per cent., Cu 3.5 per cent., Au 3 oz., Ag 37 oz.), matte (Pb 2.14 to 3.0 per cent., Cu 7.30 to 11.97 per cent., Sb 0.56 to 1 per cent., Au 0.24 oz., Ag 13.68 oz.) and slag (SiO_2 30 per cent., FeO 33 per cent., CaO 18 per cent., Al_2O_3 6 per cent.).

Smeltery Smoke.—C. Gerlach[2] describes his apparatus for collecting obnoxious gases in the field and determining their acid content as soon as collected. The collecting cylinder, about 4 ft. long and 1 ft. in diameter, is pivoted in the handles of a wheelbarrow which are made double. When the place has been reached where a sample of gas is to be taken and analyzed, the double handle is opened and righted when it has the appearance of two X-shaped frames supporting the upright cylinder. A table of results giving the determinations made with this apparatus between 1896 and 1906 is appended to the paper.

O. E. Jaeger and G. C. Westby give an illustrated description[3] of the form of Pitot tube and manometer in use at the Boston & Montana and the Anaconda works for determining the velocity of gases, and show by an example how the necessary calculations are to be carried through. Considering that the Pitot tube has had to undergo so many changes in form and is still generally distrusted as giving unreliable data, it is a relief to be furnished with a form that has proved sufficiently accurate to be accepted as standard.

C. B. Sprague patented[4] a process for neutralizing sulphuric acid and corrosive soluble metallic compounds in smeltery smoke so that it can be filtered in a baghouse. Of the different reagents, zinc oxide appears the most effective and powdered lime the cheapest. Zinc oxide is produced by blast-roasting blende on a grate similar to the Wetherill, whence the zinc fumes produced are drawn off into the main flue carrying off the furnace gases. Zinc oxide may also be fed into the flue or into the inlet of the fan which blows the gases into the baghouse. The process

[1] *Eng. and Min. Journ.* (1909), LXXXVII, 891.
[2] "Sammlung von Abhandlungen über Abgase und Rauch schäden," III.
[3] *Eng. and Min. Journ.* (1909), LXXXVIII, 468.
[4] U. S. Pat. No. 931,505, August 17, 1909; *Min. World* (1909), XXXI, 553; *The Mineral Industry* (1908), XVII,604

is in successful operation at the smelting works of the United States Smelting, Refining and Mining Company, Bingham Junction, Utah.

C. Baskerville discusses[1] the legal status of works producing obnoxious gases. Starting with the right of the individual to have air in its natural condition and free from artificial impurities distributed over his property, he shows that any interference with this right forms a nuisance and is actionable as such. The question as to what degree of impurity imparted to the atmosphere constitutes a nuisance has been discussed in various States, and some of the decisions are given. For all the statements made in the paper, legal authority is quoted in the foot-notes.

J. W. Neill[2] in reviewing the question of smeltery smoke, makes the interesting statement that at Spencerville, Cal., where several hundred thousand tons of pyrite ore were roasted in heaps, after a lapse of 12 or 14 years, no trace is to be found of the former devastation. He also deprecates the present custom of carrying on the entire metallurgical process at a centrally located plant instead of roasting at the mine, where, as for example, in Utah, the sulphurous gases could be allowed to pass off into the open, and the roasted ore then transferred to the smelting plant. An allusion is made to a successful mechanical process for handling smeltery smoke, but no further indication given of what it is.

F. T. Harvard[3] reviews statements of E. P. Mathewson regarding the different methods of rendering smeltery smoke harmless when applied to a plant of the size of that at Anaconda. Spraying with water would cost $3,000,000 and necessitate the disposal of acid mud; a baghouse plant would mean an outlay of $2,750,000 and the operation would cost $1850 per day exclusive of the cost of replacing bags which would last but a short time; air-cooling would cost $1,200,000 and would not be efficient; the freezing system would cause an expenditure of $4,000,000 for pipes alone and a daily outlay of $10,800; an establishment for the use of zinc oxide as neutralizer would cost $3,000,000 besides a daily consumption of 500 tons of zinc ore; the Cottrell method is not suited for large volumes of gas; the friction (Roesing wire) system as put in operation at Great Falls, Montana, would cost $2,000,000. The latter system was the only one considered as feasible, and will be introduced as soon as favorable results are reported from the Great Falls plant.

N. S. Stewart[4] has calculated and tabulated the numerical data for

[1] *Eng. and Min. Journ.* (1909), LXXXVIII, 884.
[2] *Min. and Sci. Press* (1909), XCVIII, 81.
[3] *Eng. and Min. Journ.* (1909), LXXXVII, 562.
[4] *Ibid.* (1909), LXXXVIII, 257.

the coördinates of catenary curves in which the ratio of hight to width of base is approximately 0.75. The tables greatly facilitate the laying out of dust flues having this cross-section of a catenary. In the paper by E. A. Lee (see below) the laying out of the catenary curve in the field is accomplished by suspending a chain from two points. The distance between these is equal to the length of the base of the flue; and the chain is of such length that the apex of the curve coincides with the centre of the crown of the arch.

E. A. Lee discusses[1] the design of smelter flues with special reference to the flues existing at various Colorado lead smelteries. As to volume and temperature of gases, with a modern lead blast furnace the volume was found to range from 12,000 to 20,000 cu.ft. per min., and the temperature from 65 to 120 deg. C. With a hand-rabbled reverberatory roasting furnace the volume was 14,000 cu.ft., and with the Pearce, Godfrey, and other mechanical furnaces 10,000 cu.ft. The temperatures with both classes of roasters ranged from 260 to 370 deg. C. With a Huntington-Heberlein converter the volume was 1000 cu.ft., and the temperature from atmospheric to 230 deg. C. The loss in temperature in 100 ft. of brick flue with sides 13 in. and roof 9 in. in thickness was 0.154 deg. C. for every degree of difference between the temperature of the gases and of the atmosphere. The velocity of gases in the flues for proper settlement of dust was found to be 450 ft. per min. In case dust chambers are used, the velocity in the connecting flues may reach 1600 ft. The dust recovered varies in amount from 0.2 to 2 per cent. of the weight of the ore. It weighs about 75 lb. per cu. ft., or a ton occupies a space of 27 cu. ft.

The length of the flues in Colorado show a range of from 500 to 2000 ft. The ratio of their volume to that of gases passing through per minute is from 2 : 1 to 4 : 1 for blast-furnace gases and from 2 : 1 to 1 : 1 for roaster gases. The building material ordinarily used is red brick. It is frequently painted inside and outside with tar, the main advantage of the coating being that it prevents moisture from entering the flue. Steel flues are frequently employed for blast-furnace gases, as these have low temperatures and contain little sulphur dioxide and moisture. Thus the main flue of the Globe smeltery at Denver, of $\frac{3}{16}$-in. steel, was erected 16 years ago and is still in good condition. Steel is not suited for roasting-furnace flues on account of the corrosion due to moist sulphurous gases, and loss in draft due to the cooling of the gases. Protective paints have not been used with much success. Cement is unsuited for sulphurous gases. Vitrified brick has been found

[1] *Bull.*, Tech. and Eng. Soc., Colorado School of Mines (1909), IV, 197; *Min. Sci.* (1909), LX, 556.

to be the best material for flues carrying gases high in sulphurous acid, as e.g., the gases from blende-roasting muffle furnaces and Huntington-Heberlein blast-roasting pots.

Fig. 1, representing a cross-section of a flue recently built for roaster gases at Durango, Colorado, depicts a common form. The footing, of concrete, is from 15 to 24 in. deep and 16 to 18 in. wide. The thrust of the arch is calculated according to the formula $T=1.5wL^2/r$ in which T equals the horizontal component of the arch thrust in pounds per linear foot of arch; w=weight of arch and superimposed load in pounds per square foot; L=length of span in feet; r=rise of arch in inches.

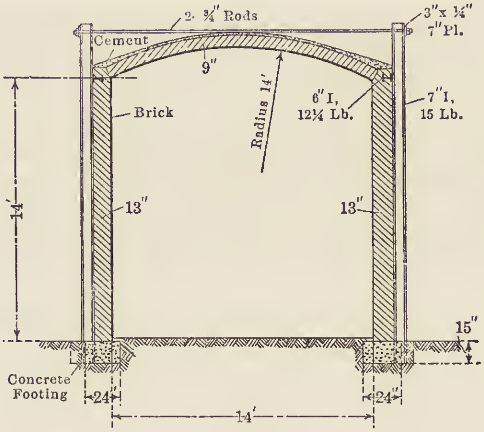


FIG. 1.

The buckstaves, skewbacks and tie-rods are so calculated as not to be strained above the elastic limit, should one set fail. Thus with buckstays and tie-rods of mild steel, the working stress taken is 16,000 lb. per sq. in. and with skewbacks 28,000 lb. In calculating the footing, the bearing power of the soil is taken as two tons per square foot. The compressive strength of ordinary brick is taken as 200 lb. per sq. in. while stresses due to wind pressure are not considered as long as the hight of a flue does not exceed 14 ft. In rectangular flues in which the buckstays can be omitted, the thrust of the roof on the skewbacks is taken up by tie-rods passing through the flue. They are incased in iron or lead pipe for protection against corrosion by sulphurous gases.

A form of flue that is coming more and more into use is the one shown in Fig. 2, which is built in the form of an inverted catenary. The most economic cross-section is obtained by making the hight 75 per cent. of the base and the cross-sectional area 55 per cent. of the square of the base. A flue of 9-in. brick, 16 ft. high and 22 ft. wide at the base, can stand a wind pressure of from 10 to 12 lb. per sq. ft. of exposed area, and this is as high a pressure as is ever reached in sheltered localities. In order to guard against accidents due to distortion caused by settlement, excessive external load or corrosion on the inside, some flues recently built have been strengthened by ribs of reinforced concrete, spaced from 6 to 10 ft. apart, as shown in Fig. 2. In a flue, expansion joints, 2 in. wide, are provided every 100 ft. They are covered with one thickness of brick laid dry. An acid-proof mortar for laying a 4-in. course of vitrified brick consists of barite mixed with a 10-per-cent. solution of water-glass; commercial water-glass contains 50 per cent. Na_2SiO_3.

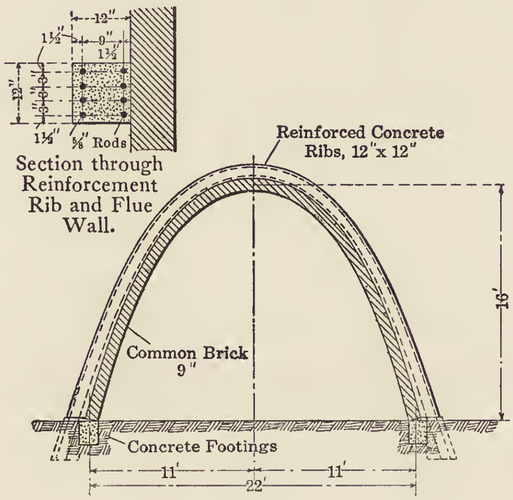


FIG. 2.

L. F. Bassett suggests[1] a method of rendering smeltery fume harmless. In most regions there is a prevailing direction of wind. If a flue is constructed at right angles to this direction, and openings are provided at intervals of 100 ft. from which a small portion of the gases is allowed to escape, the gas will be sufficiently diluted by the surrounding air to be practically harmless.

The Roesing wire system for recovering fluedust from furnace gases which was introduced years ago at the silver-lead works of Tarnowitz, Silesia,[2] has been installed at the works of the Boston & Montana Mining Company, Great Falls, Montana.[3] The results of this new condensation plant in which 1,215,000 wires (No. 10 and 12 B.W.G., 20 ft. long and weighing about 608 tons) are suspended, will be awaited with interest.

[1] *Min. and Sci. Press* (1909), XCVIII, 381.
[2] Hofman, "Metallurgy of Lead" (1909), 392.
[3] R. L. Herrick, *Mines and Minerals* (1909), XXX, 258; C. W. Goodale, *Bull.*, A. I. M. E., January, 1910, 73.

C. T. Rice discusses[1] the neutralization of acid gases by the Sprague process and the filtration of fumes as practised at the works of the United States Smelting, Refining and Mining Company at Bingham Junction, Utah. The presence of SO_3 and soluble metallic sulphates in furnace gases makes filtration through bags impractical, as the bags, both woolen and cotton, are quickly ruined. Sprague's remedy is to use zinc oxide and burnt lime as neutralizing agents. Zinc oxide is prepared by treating blende, mixed with about 30 per cent. of fine coal, on a Wetherill grate, as is done in the F. L. Bartlett process at Canyon City, Colo. for the treatment of mixed zinc-lead sulphides.[2] The oxide-laden gases are conducted into the main flue leading to the baghouse. Any lack of zinc oxide obtained in this way is made up by feeding burnt lime into the flue. As this is not as active as zinc oxide, the neutralization is effected by feeding zinc oxide into the flue after the lime has done its work. As neutralization is satisfactorily accomplished only at a temperature belok 120 deg. C., the gases from the blast-roasters and reverberatory furnaces have to be cooled.

The gases from blast-roasters treating 300 tons of ore in 24 hours, carry about 400 lb. of sulphuric acid and those from hand-rabbled reverberatory furnaces treating 70 tons of matte in 24 hours about 2500 lb. of acid. The average temperature of the blast-roaster gases is 100 deg. C. (range 60 to 160 deg.) and that of the reverberatory furnace gases 275 deg. C. The converter gases are sufficiently cool for neutralization after they have traveled through a brick flue 250 ft. long. The gases from the reverberatory furnaces are conducted through several series of long steel flues placed between brick settling chambers so as to reduce their temperature to 120 deg. C., when they join the gases from the blast-roasters. As gases with a temperature above 100 deg. C. attack even woolen bags quickly, the temperature of the above gas mixture has to be brought down from 120 to 100 deg. C. by additional cooling flues. The gases from the blast furnaces with a temperature of from 80 to 100 deg. C. go direct to the baghouse.

The baghouse,[3] which is provided with the Benedict shaking device,[4] has eight bays. The gases from the six blast furnaces, amounting to 200,000 cu.ft. per min., are filtered in five bays, each of which has 416 cotton bags 31 ft. long and 20 in. in diameter. The roaster gases, 150,000 and 175,000 cu.ft. per min., are filtered in three bays, each of which has 420 woolen bags of the same size as the cotton bags. It has been

[1] *Mines and Methods* (1909), I, 9.
[2] *The Mineral Industry* (1896), V, 619, Hofmon, "Lead" (1899)) 138.
[3] *Ibid.* (1907), XVI, 669.
[4] *Ibid.* ((1908), XVII, 602.

found that the life of a bag is greatly increased if the filtered gases are drawn away through a chimney instead of being allowed to pass off into the open through the shutters which usually close the window openings of the baghouse. In the five-bay blast-furnace division, a monitor flue passing over the centers of the five bays carries the gases to a single stack 245 ft. high and 16½ ft. in diameter. In the three-bay roaster division, each bay is served by a separate stack, 100 ft. high and 6½ ft. in diameter, which is placed on top of the bay and supported by a steel breeching from the roof trusses. The baghouse dust, of which about 20 tons are produced daily from 800 to 900 tons of ore with less than 10 per cent. sulphur, contains from 17 to 30 per cent. arsenious oxide. It has been found that the dust in the cellar underneath the thimble floor frequently ignites of its own accord. It is treated in two 16-ft. Brunton furnaces and the fumes are conducted through two brick chambers, each with a floor area of 2268 sq.ft., having partition walls to cause the gases to zig-zag through them. The crude arsenic assays 97 to 99 per cent., As_2O_3. After retreatment, the grade is raised to 99.8 per cent. The residue from the furnace retains 10 to 12 per cent. As_2O_3. The cost of cooling and neutralizing the gases and of refining the arsenic, including repairs and upkeep, is approximately $6000 per month. The profit from the baghouse is about $1200 a month.

W. C. Ebaugh discusses[1] the baghouse and its recent application in the filtering of furnace fumes carrying sulphurous gases. The ordinary baghouse carries from 3000 to 4500 bags, usually 18 in. in diameter and from 30 to 33 ft. long. In blast-furnace work it was formerly thought that from 750 to 1150 sq.ft. of filtering surface were required per ton of charge. At present from 300 to 500 sq.ft. are considered to be more than sufficient. The filtering medium is cotton cloth having from 42 to 50 threads to the linear inch and weighing from 0.4 to 0.7 oz. per sq.ft. Cotton, however, becomes brittle when the temperature of the gases exceeds 90-95 deg. C., and is corroded by acid when it sinks to 45 deg. C. Woolen bags resist temperatures of 120 to 135 deg. C. and are less liable to corrosion than cotton. Temperatures ranging from 65 to 80 deg. C. are considered best. The furnace gases are either air-cooled or diluted with air to bring them to this range of temperature.

The author briefly reviews the experiments made by the late R. D. Rhodes and C. B. Sprague between 1907 and 1909 at Bingham Junction, Utah (see Sprague above). Gases from smelting and converting furnaces are readily neutralized, although MacDougall and reverberatory roasting furnaces carry too much sulphuric acid to make the process a com-

[1] *Journ. Ind. and Eng. Chem.* (1909), I, 686; *Eng. and Min. Journ.*, LXXXVIII, 1020.

mercial success.[1] He then discusses the different methods of shaking the bags and speaks in favor of the Benedict device;[2] takes up the usual method of igniting and heap-roasting the dust settled in the chamber or cellar underneath the bag division; refers to the precautions that workmen have to take who work in the baghouses; brings out the disadvantages (cost of plant, of maintenance, of artificial draft, collection of arsenic, difficulty of disposing of it); and states the advantages (greater yield of metal, regularity of draft and ventilation, less injury to man and surrounding country, avoidance of lawsuits and damages, etc.)

An editorial[3] states in a brief review of the subject that at the Selby works[4] near San Francisco the treatment of furnace gases by the Cottrell process to render them suitable for filtration in a baghouse has been abandoned, and that the process is restricted now to the gases and fumes issuing from the parting plant.

Another interesting fact is that the United States Smelting, Refining and Mining Company, at Bingham Junction, Utah, has been permitted by the Federal Court to start its copper department again, provided that it neutralizes all sulphur trioxide and sulphuric acid in the gases with zinc oxide or lime or both, that it removes all solid matter in them by filtration and that it dilutes the gases to such an extent that when passing off into the open at a suitable hight they shall not contain more than 0.75 per cent. of sulphur dioxide by volume.

Lead Poisoning.—The seventh report of the Austrian Commission appointed for investigating the causes of lead poisoning and the necessary remedies appeared in 1909.[5] It covers 78 quarto pages and takes up printing and type-founding establishments.

Desilverization.

Parkes Process.—D. Coda patented[6] a process for the recovery of the 0.7 per cent. zinc which lead retains after it has been desilverized by the Parkes process. It consists in adding to the lead in the kettle an alloy of copper or copper-aluminum and lead, e.g., 5Cu : 94Pb, which has the property of taking up 10 per cent. of its weight of zinc and of forming a crust which, floating on the lead, is readily skimmed off. The zinc can be recovered by distillation as is common with zinc-silver-lead crusts.

Electrolysis of Lead Solutions.—R. P. Jarvis and S. F. Kern[7] investigated the effect of "addition agents," such as gelatine, tannin, pyrogallol

---

[1] At Bingham Junction gases from roasting furnaces are now neutralized with lime and zinc oxide and then filtered.
[2] *The Mineral Industry* (1908), XVII, 602.
[3] *Mines and Methods* (1909), I, 2.
[4] *The Mineral Industry*, (1908), XVII, 603.
[5] A. Hölder, Vienna.
[6] German Pat. No. 207,019.
[7] *Sch. Mines Quart.* (1908–09), XXX, 100; *Electrochem. and Met. Ind.* (1909), VII, 271.

and resorcinol, upon the smoothness of the cathode deposit in the electrolytic refining and electro-plating of copper, lead, silver, nickel and iron from various solutions. Lead tends to form crystalline and less coherent deposits with high rather than low curent densities. A rise of temperature in the electrolyte up to 60 deg. C. gives deposits that are more coherent and dense, and less crystalline than when the temperatures are low. Lead fluosilicate gives a smoother deposit than lead nitrate. An addition of one part of either tannin, resorcinol, pyrogallol or gelatine, to 250 parts of an almost neutral electrolyte of lead nitrate, furnishes a deposit of loosely coherent crystals. Tannin is more satisfactory in this respect than the other reagents. An addition of one part of either gelatine, tannin or pyrogallol to 5000 parts of a lead fluosilicate solution gives a smooth, dense, coherent deposit. With the fluosilicate gelatine is the most effective addition agent, then follows tannin and pyrogallol. Resorcinol is not suited for use with this electrolyte.

Betts Process.—A. G. Betts has written a paper[1] on the present state of his process for the electrolytic refining of argentiferous lead. Three plants are in operation; one at Trail, B. C., one at Grasselli, Ind., and one at Newcastle-upon-Tyne. The electrolyte contains eight grams lead and 15 to 16 grams SiF_6 in 100 c.c., and after being in use for some time 0.2 to 0.3 per cent. free HF. From 400 to 500 grams of gelatine are added for each 1000 kg. of lead deposited. The electrolyte is kept at from 30 to 35 deg. C., at which temperature the resistance is 3.6 ohms per cu.m. With an electrode distance of 1¾ in. and a current density of 15 amp. per sq.ft., the e.m.f. for a vat is 0.22 volt and adding to this 0.1 volt to overcome other resistance, gives a total of 0.32 volt. With an increase of lead in the electrolyte above eight grams per 100 c.c., a higher voltage is found to be necessary. The electric efficiency reaches 90 per cent., but often falls to 85 and 88 per cent. The three plants mentioned above use currents ranging from 3500 to 5000 amp. The circulation is effected by having the vats arranged in cascades. The vertical distances between the vats are made as small as possible, as entrained oxygen has a tendency to oxidize floating particles of Sb which are dissolved and then deposited on the cathode, and to cause an enrichment in lead of the electrolyte. The anode scrap varies from 25 to 33 per cent. The anode mud which adheres to the anode is scraped off, washed and filtered in a press when it retains less than one per cent. $PbSiF_6$. The first wash water goes directly to the electrolyte sump, as it does the greater part of the wash water after it is evaporated to the required concentration. Weak

[1] *Metallurgie* (1909), VI, 233.

wash waters are stored to be used again as first wash waters. It is necessary to heat them as cold mud cannot be washed satisfactorily.

Each plant makes its own HF, a solution of which contains 33 per cent. HF and costs about 1.5c. per lb. The anodes are cast in vertical closed, or in horizontal open molds. They are 1 in. thick and, excluding the suspension shoulders, 36 in. long by 24 in. wide. A vat holds from 22 to 28 anodes and from 23 to 29 cathodes. At least two cathodes have to be kept on hand for every anode, as the former is exchanged every fourth or fifth day. The method of casting the cathodes has already been described. The vats are of wood coated with asphalt, but as this coating cracks when the electrolyte is too cool, and blisters when it is too hot, it is the intention to replace it by cement. The vats are charged and discharged from overhead cranes. The washed anode mud is discharged from the press onto trays resting on cars. The cars are then run into a dust flue where the mud is dried and partly oxidized. The mud is melted down in a basic reverberatory furnace. The products are antimony slag, occasionally some silver-bearing copper matte, and doré silver carrying bismuth. The fluedust formed is rich in antimony and especially so in arsenic, as only 5 per cent. of the arsenic is slagged. Plans are under way for treating the anode mud in a different manner in order to recover the antimony as well as the bismuth in the metallic state. The cost of treatment with a plant of from 60 to 100 tons' daily capacity, excluding general expenses, is given as $4 per ton. The loss in H_2SiF_6 is from 3 to 5 lb. per 1000 lb. refined lead and the loss in lead 0.25 per cent.

To the above the reviewer may add that electrolytically refined lead always contains more silver than lead obtained in the Parkes process, and that the oxidation of floating metallic antimony particles makes it necessary to pole the melted cathode lead in order to reduce the antimony to the required degree. The cathode lead, however, is free from bismuth, and it is the presence of this latter metal in lead from the Parkes process that forms its leading disadvantage as compared with the Betts process.

A. J. McNab[1] has patented a process for working up the anode mud of the Betts electrolytic lead-refining process: It consists of: (1) Solution of Sb, As, Te and Se in sodium polysulphide and electro-deposition of antimony from the filtered solution; accumulating arsenic is to be removed by concentration of liquor to 35 deg. B. and subsequent cooling. (2) Sulphatizing roast of the residue (Ag, Pb, Bi, Cu, Au); extraction of copper (also some Ag and Bi) with water and sulphuric acid; pre-

[1] U. S. Pat. No. 905,753, Dec. 1, 1908.

cipitation of silver and bismuth with copper; fusion of the residue and separation of silver and bismuth by cupellation; recovery of bismuth by known methods; concentration of the copper solution, etc. (3) Fusion of the residue (Au, Ag, Pb, Bi) from leaching the sulphatized material, in a reverberatory furnace; separation of lead and bismuth from gold and silver by cupellation; and recovery of bismuth by known methods.

A. G. Betts has patented[1] a new method for working up the anode mud produced in his process for electrolytic refining of lead bullion. The anode mud is treated in a tank in the presence of lead peroxide and fluosilicic and hydrofluoric acids to dissolve the Cu, Ag, Bi, As, Sb, and Sn. The residue (Au, undissolved Ag, and excess PbO_2) is filtered off. The filtrate is freed from silver by means of copper and then electrolyzed, using carbon anodes to plate out first the copper, then an alloy of copper and antimony, then impure lead, and lastly pure lead, Lead peroxide is deposited on the anode, from which it is removed, ground, and used again in the slime treatment.

---

[1] U. S. Pat., No. 918,647, April 20, 1909.

LITHIA.

The Black Hills of South Dakota afford the entire production of minerals used for the extraction of lithia in the United States. The three minerals mined for this purpose are spodumene, lithiophilite and amblygonite, all of which are found in connection with tin ores in pegmatite dikes in Custer and Pennington counties.

At the Etta mine, 16 miles east of Hill City, which belongs to the Pahasa Mining Company, successors to the Harney Peak Mining Company, large exposures of spodumene have been opened by leasers, and shipments have been made, from time to time, for several years to the Standard Essence Company, of Maywood, N. J. As the spodumene is mined, it is piled up on the dump and shipments are made as required. In this way several hundred tons have accumulated at the mine. The Ingersoll group of mines, also the property of the Pahasa company, affords an output of amblygonite, recovered by the operations of leasers. A recent shipment of a carload, which was exported to France, contained over 8 per cent. lithia. Other mines, near Keystone, are operated by the Western Chemical Reduction Company, of East Omaha, Nebraska. Since 1905, this company has mined about 300 tons of amblygonite which was worked up into lithium carbonate. The production of spodumene from the Etta mine has for many years varied between a maximum of 200 tons and a minimum of 50 tons. The Pahasa company reported no production in 1909 from any of its properties.

On account of competition and low prices the lithia business in 1909 was rather unremunerative. Large quantities of lithium carbonate were sold at 30c. per lb., and the average price was not over 32c. At the end of the year large stocks were taken over in anticipation of an increase in price, but a decreased demand due to the use of coal-tar products as a substitute prevented an advance.

STATISTICS OF LITHIUM ORE AND SALTS IN THE UNITED STATES. (*a*)
(Tons of 2000 lb.)

Year.	Production. (*b*)		Imports. (*c*)		Year.	Production. (*b*)		Imports. (*c*)	
	Tons.	Value.	Pounds.	Value.		Tons.	Value.	Pounds.	Value.
1902......	1,245	$25,750	21,216	$22,951	1906....	383	$ 7,411	*Nil.*	....
1903......	1,115	23,425	5,596	3,669	1907....	530	11,000	60	$100
1904......	577	5,155	19	48	1908....	203	1,550	*Nil.*	....
1905......	79	1,412	*Nil.*	....	1909....	150	1,000	*Nil.*	....

(*a*) Statistics of the U. S. Geological Survey except for 1909. (*b*) Ore. (*c*) Lithia Salts.

MAGNESITE.

The mining of magnesite on a commercial scale in the United States was conducted during 1909 in the State of California only. Even there but few of the known deposits are being utilized, for the reason that the Pacific coast demand is comparatively light and the substance will not profitably bear transportation charges across the continent to points of greatest consumption. Large quantities are therefore annually imported from Greece and Austria.

In California the principal use to which the mineral is put is, in a calcined form, as a digester of wood pulp in paper manufacture. Some is also used for manufacturing carbonic-acid gas and smaller quantities in making tiling and other building materials. The normal annual demand from the California mines is from 6000 to 8000 tons of crude material, but a much larger output could be made did consumption warrant. The spot price at the principal mines in the San Joaquin valley was $3 per ton for the crude. The calcined was sold at $14@16 per ton, according to the roast given. It takes 2.6 tons crude to make one ton of calcined magnesite. Nearly all that is mined is calcined at the mines before shipment, there being little or no demand for the crude mineral. The only crude magnesite shipped from the mines is that used in the manufacture of carbonic-acid gas. In this process the mineral is calcined, the gas saved, and the calcined sold to the paper makers. For building material only the calcined is utilized.

During 1909 an increased amount of building material was made, though most of the manufacturers conducted their business on a small scale, no extensive plants having been erected since the destruction of the works of the American Magnesite Company at East Oakland by the earthquake of 1906. That company has since virtually gone out of business and its mines at Red Mountain were relocated by others.

The first attempts to manufacture flooring and kindred substances in California were not successful owing to lack of knowledge of the proper binder. These difficulties having been overcome to a great extent, the products now turned out are fairly satisfactory. The first failures did some harm to the industry and it is still difficult to get architects and contractors to name this substance as a building material. Although of late large quantities are being put in use in prominent and expensive buildings, it will be necessary for a large company with extensive capital to establish a plant where the work can be conducted upon a scientific basis and thus insure uniform products which will stand the necessary tests.

More interest was manifested in magnesite in 1909 than ever before, but this did not lead to the opening of any new deposits of magnitude. Several companies were organized to manufacture building materials, etc., and to mine the substance, but their efforts were mainly directed toward selling stock and they did not open new mines or build plants. Of the factories that operated, all were small and each man seemed to be working on some plan or secret process of his own, making just enough to fill immediate contracts and extending the business but slowly.

STATISTICS OF MAGNESITE IN THE UNITED STATES.
(Tons of 2000 lb.)

Year.	Production. (a)		Imports.		Consumption.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1897	1,143	$13,671	(b)	....	....	....
1898	1,263	19,075	16,039	$134,130	17,302	$153,205
1899	1,280	18,480	20,807	(e) 174,779	22,087	193,259
1900	2,252	19,333	28,821	(e) 216,158	31,073	235,491
1901	4,726	43,057	33,461	(e) 250,958	38,187	294,015
1902	2,830	20,655	49,786	373,928	52,616	394,583
1903	1,361	20,515	54,776	461,399	56,137	481,914
1904	2,850	9,298	38,704	286,828	41,554	296,126
1905	3,933	16,221	74,374	638,619	78,307	654,840
1906	4,032	40,320	90,396	863,492	94,428	903,812
1907	6,405	57,720	99,008	875,359	105,413	933,079
1908	8,967	52,342	84,494	736,763	93,461	789,105
1909	7,942	62,588	114,292	985,019	122,234	1,047,607

(a) Reported by the State Mining Bureau of California. (b) Not reported. (e) Estimated.

The most productive mines in the State were operated in the interest of the manufacturers of paper from wood pulp, who utilized almost the entire output. These mines are at South Tule and Porterville, Tulare county, and are provided with their own calcining furnaces. Another mine which is equipped with furnaces is in Fresno county, near Sanger, but it was not in operation during 1909, owing to cost of the long haul to the railroad. The deposit at Winchester, in Riverside county, was also worked in a small way. Small quantities were also taken from the Red Mountain deposits in Santa Clara and Stanislaus counties, but the distance from rail connection prevented mining these deposits on a large scale. A 21-mile railroad must be built before it will pay to work these mines extensively. There is quite a group of them and more or less development work has been done, showing, on the surface at least, apparently large bodies of mineral.

Although there are several known deposits of some extent in both Sonoma and Napa counties, there was little or no production from these sources; formerly the Napa county mines were the most productive in the State. Some of the mines near railroads have been worked out, and those where long hauls are necessary cannot compete with mines in other counties where shipping facilities are better.

One of the difficulties in the mining of magnesite is that of knowing with anything like exactness the extent and continuity of the deposits. They may give out at any time, or intrusions of serpentine may unexpectedly cut them off. Often there are immense croppings with not very much below them. On account of this uncertainty as to the extent of the deposits and the small local demand, few deposits have been exploited. A very complete description of the magnesite deposits of California was published in *Bulletin* 355 of the U. S. Geological Survey, by Frank L. Hess. A map accompanies this bulletin and shows the situation of all known mines or deposits.

Magnesite Mining in Foreign Countries.

Austria.—The magnesite works, at Radenthein, Austria, owned by the American Refractories Company, of Chicago, was started Oct. 4, 1909, by the firing of the first kilns, and began deliveries of magnesite in the United States later in the year. Construction has now been going on for over one year, and the works are equipped with the most modern apparatus for calcining magnesite, including kilns fired with producer gas magnesite separators, electrical cleaning devices, etc. The plant starts out with a yearly capacity of 60,000 tons of dead-burned magnesite. This material is shipped in strong jute bags, and arrangements have been made for the carrying of large stocks of magnesite at the ports of Philadelphia, New Orleans and New York. It is the intention of the company to increase the capacity of the magnesite works as rapidly as possible up to a yearly capacity of 120,000 tons.

Greece.—Magnesite is found principally in the island of Eubœa, in veins 15 to 20 m. in thickness, and several kilometers in length. It is mined by the Company of Municipal and Public Works, the Anglo-Greek Company, and the Magnesite Company. It is exported (1) in a crude state at $3.70 per ton; (2) calcined, at about $13 per ton; (3) dead-burned, at $14 per ton; (4) in brick, at about $14.50 per thousand. There is great demand for Greek magnesite at present, and the possible output has been ordered for some time in advance.

India.—The principal deposits lie in the Chalk hills, near Salem, in the Madras presidency. Salem is 200 miles west of Madras and the same distance east of the port of Beypore; the Madras Railway, connecting these two ports, passes within a mile of the deposits. The magnesite covers a superficial area of about 2000 acres and occurs in numerous irregular veins which ramify an ultrabasic intrusion of eruptive dunite. Generally the magnesite is nearly white; it has a specific gravity of 3, and a hardness of about 5. Shipments of the mineral recently made show from 97 to 98 per cent. magnesium carbonate, with an exceptionally low content of lime, silica, alumina and oxide of iron. A modern calcining plant for the production of caustic and dead-burned magnesia has been erected near the quarries. The production in 1908 amounted to 7534 long tons.

THE PRINCIPAL SUPPLIES OF MAGNESITE.
(In metric tons.)

Year.	Austria-Hungary. (a)	Greece. (d)	India. (d)	United States. (d)
1897	(b)	11,311	(e)	1,038
1898	(b)	14,829	(e)	1,146
1899	(b)	17,184	(e)	1,161
1900	(b)	17,277	(e)	2,043
1901	40,236	20,348	(e)	4,286
1902	53,467	23,020	3,597	2,567
1903	69,058	28,415	838	1,234
1904	53,781	9,133	1,193	2,585
1905	92,359	37,063	2,645	3,568
1906	87,765	40,584	1,861	3,658
1907	113,695	55,816	188	5,809
1908	(e)	63,079	7,655	4,507

(a) Exports of calcined magnesite. (b) Previous to 1901 magnesite was included with other minerals not elsewhere specified. (d) Crude magnesite. (e) Not reported.

ANALYSES OF MAGNESITE AND ITS PRODUCTS. (a)

	Greek Magnesite	Indian Magnesite	Indian Caustic Magnesia (b)	Indian Dead-burnt Magnesia.(b)	Styrian Dead-burnt Magnesia.	Indian Magnesite Bricks.
Combined water	....	1.30	....	....	....	....
Loss on ignition	....	....	2.31	0.34	....	....
Silica	1.63	1.17	....	4.38	2.20	3.15
Iron oxides	1.19	0.14	0.44	1.02	7.70	0.53
Alumina	0.17			0.10	1.02	0.23
Manganese oxide	....	0.06	....	....	....	....
Phosphoric acid	....	0.01	....	....	....	....
Sulphuric acid	....	0.03	....	....	....	....
Lime	1.44	0.78	1.03	1.04	4.92	1.61
Magnesia	45.75	46.28	96.10	93.12	83.92	94.28
Carbon dioxide	49.88	50.10	....	....	....	....
Magnesium Carbonate	(95.63)	(96.34)	....	....	....	....
Insoluble residue	....	....	0.54	....	....	....

(a) H. H. Dains, *Journ.*, Soc. Chem. Ind., Vol. XXVII, No. 10, p. 503. (b) Burned in gas-fired kiln.

Technology of Magnesite.

A paper by H. H. Dains, read before the Society of Chemical Industry, primarily describing the magnesite deposits of India, contains some valuable information in regard to the preparation of magnesite for its various uses.

Magnesite in the raw state is used chiefly for the manufacture of carbonic-acid gas. In the United States, the gas is obtained by calcination of the crude magnesite in retorts. The residue is then sold to the manufacturers of refractory bricks, and also to the manufacturers of paper. In some works the carbonic-acid gas is evolved by the action of sulphuric acid on the crude magnesite.

Calcined magnesite may be classed according to the temperature at which the calcination takes place, as follows: (a) lightly calcined or caustic magnesia; (b) dead-burnt, sintered, or shrunk magnesia. The caustic magnesia is obtained by calcining at a temperature of 800 deg., and the process is best carried out in a kiln fired with gas. It is largely used for Sorel cement, plaster, steam packing, and many other purposes. In India, caustic magnesia was first obtained by calcining in ordinary lime kilns. The quality of the product was inferior owing to contamination with ashes. A regenerative gas-fired kiln has since been erected and is now working satisfactorily. The quality of the product is much better, containing 96 per cent. of magnesia, as against only 91 per cent. secured by the older process. The standard quality stipulated by European consumers is 85 to 90 per cent. magnesia with lime not exceeding 4 per cent.

Sorel cement is formed by mixing caustic magnesia with a solution of magnesium chloride of specific gravity 1.162 to 1.263. This cement is hard, white and very durable and will carry up to 20 parts of sand to one of magnesia. When used with sawdust as an aggregate, it makes a practically noiseless and dustless flooring.

Dead-burnt, or shrunk magnesia, is obtained by calcining at a temperature of not less than 1700 deg. C. At the Indian locality calcination is carried out in a Schneider kiln, but a gas-fired kiln would be preferable. The product obtained by dead burning is very basic, has a specific gravity of 3.5, is free from carbon dioxide, and has practically no tendency to absorb water.

The principal uses of dead-burnt magnesia are as refractory lining for open-hearth basic furnaces and converters in the steel industry, for linings in rotary cement kilns, for furnace hearths, crucibles, etc., and refractory bricks. The most refractory magnesia is obtained from magnesite containing little or no lime, silica, oxide of iron, or alumina. The presence of much lime in magnesite bricks used at high temperatures cause them to disintegrate. In basic-steel furnaces, the presence of lime is said to cause the phosphorous to pass into the hearth instead of into the slag. To secure a good grade of dead-burnt magnesite a very high temperature must be used, not only to drive off all the carbon dioxide, but to shrink the magnesia. Dead-burnt magnesia has replaced dolomite to a great extent in basic open-hearth furnaces because it is not hygroscopic, and can therefore be kept any length of time without deterioration. Dolomite is useless after being once used and 550 to 1100 lb. are required for repairs after each heat, while with dead-burnt magnesite only 110 to 220 lb. are required.

Magnesite is sometimes calcined in electric furnaces. When this process is used the magnesia becomes partly fused, and the resulting product is a crystalline mass of thoroughly shrunk material having a specific gravity of 3.58. This material has been used with much success as a lining for electric furnaces.

In England, magnesite bricks are usually made by grinding the dead-burnt magnesite in a form of Chilean mill, mixing with water in sufficient quantity to make a plastic mass, and molding in an ordinary hand brick press. After careful drying, the bricks are burnt in a kiln at a high temperature. The usual practice in Europe is to mix the brown calcined material with tar, mold, place in a hydraulic press, and after drying burn in a gas-fired kiln. The volatile portions of the tar escape, leaving a carbonaceous residue which binds the brick together.

MANGANESE.

By E. K. Judd.

During 1909, the mining of true manganese ore in the United States suffered a marked decline from a condition which had never been very prosperous. Practically all of the mines near Batesville, Ark., have gone out of business; those around Cartersville, Ga., have lain idle for many years; development of the California deposits made no progress. The two largest mines in Virginia, at Crimora, yielded no output in 1909, and most of the numerous small operations elsewhere in the State were also idle; two or three comparatively new mines reported small shipments for experimental purposes.

A number of causes combine to discourage the mining of true manganese ores in this country, of which the following may be noted: (1) The deposits, with few exceptions, are of such small size and poorly defined character as to preclude economical working. (2) The price of the ore is controlled by the United States Steel Corporation, which is the principal consumer. (3) The deposits of Russia, Brazil and India excel in size and in quality of ore; mining is done cheaply, ocean freights to this country are low, the ores are imported free of duty, and the consuming centers are not far from the Atlantic coast. At present, most of the high-grade, true manganese ore mined in the United States is consumed by the brick, glass and chemical manufacturing industries.

Other manganiferous materials in the United States are supplied, in order of their importance, from the following sources: (1) The iron ore produced by some of the Lake Superior ranges contains from 5 to 20 per cent. of manganese; ore of this grade is smelted into a high-manganese pig iron, but no special attention is paid to ores of low manganese content. (2) The zinc ore of Franklin Furnace, N. J., after it has yielded its zinc, affords a manganiferous residue which is then smelted into spiegeleisen. (3) Some of the silver ores of Leadville, Colo., contain enough manganese (as high as 40 per cent., averaging 25 per cent.) and iron to render the silver of minor importance; such ores are smelted into spiegeleisen. Other ores, of negligible silver contents, but averaging 15 per cent. manganese, are mined and shipped to the lead and copper smelteries to be used as flux.

In comparing the accompanying tables of production and imports of manganese ores, it should be borne in mind that the figures representing total domestic production include a preponderating tonnage of low-manganese materials, while the imports consist almost entirely of ores containing at least 50 per cent. manganese.

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES. (*a*)
(Tons of 2240 lb.)

Year.	Manganese Ores.				Manganiferous Iron Ores.				Man.Zinc Ores.	Total Production.	
	California.	Georgia.	Virginia.	Other States.	Arkansas.	Colorado.	Lake Superior.	Va. & N. C.	New Jersey.	Long Tons.	Value.
1897..	450	962	2,408	190	4,430	18,600	80,260	....	50,000	(*b*)158,600	$328,176
1898..	393	2,477	3,307	1,250	2,775	17,792	112,318	....	47,470	187.782	16 627
1899..	263	1,623	3,626	105	855	29,161	53,702	....	53,921	143,256	306,476
1900..	131	3,447	7,881	312	*Nil.*	43,393	75,360	*Nil.*	87,110	217,546	1,172,447
1901..	610	4,074	4,275	3,036	*Nil.*	62,385	512,084	20	52,311	638,795	1 644,117
1902..	846	3,500	3,041	90	*Nil.*	13,275	884,939	3,000	65,246	973,937	2,145,783
1903..	16	500	1,801	508	*Nil.*	14,856	566,835	2,802	73,264	660,582	1,670.349
1904..	60	*Nil.*	3,054	32	600	17,074	365,572	*Nil.*	68,189	454,581	789,132
1905..	1	150	3,947	(*e*) 20	3,321	45,837	720,090	*Nil.*	90,289	863,663	1,681,472
1906..	1	.....	6,028	892	8,900	32,400	1,000,008	*Nil.*	93,461	1,141,681	(*e*)3,403,993
1907 .	100	*Nil.*	(*d*) 4,604	900	4,133	(*d*) 99,711	(*e*)1,120,000	*Nil.*	93,413	1,322,861	(*e*)3,860,265
1908..	321	*Nil.*	(*c*) 6,144	200	*Nil.*	(*d*) 35,581	(*e*) 495,000	*Nil.*	110,225	647,471	(*e*)1,300,000
1909..	3	*Nil.*	(*f*)	(*f*)	*Nil.*	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	....

(*a*) Statistics of 1900-1906 are by the U. S. Geological Survey. (*b*) Includes 1300 tons of manganiferous iron ore from Vermont. (*c*) As reported by Virginia Geological Survey. (*d*) As reported by U. S. Geological Survey. (*e*) Estimated. (*f*) Figures not yet available.

CONSUMPTION OF MANGANESE ORE IN THE UNITED STATES.
(Tons of 2240 lb.)

Year.	Imports.		Consumption.		Production of Man. Silver Ores. (*b*)	
	Long Tons.	Value.	Long Tons.	Value.	Long Tons.	Value.
1897	119,961	$1,023,824	278,561	$1,352,000	149,562	$424,151
1898	114,885	831,967	302,667	1,248,594	99,651	295,412
1899	188,349	1,584,528	331,605	1,891.004	79,855	266,343
1900	256,252	2,042,361	473,798	3,214,808	188,509	897,068
1901	165, 22	1,486,573	804,568	3,130,690	228,187	865,959
1902	235,576	1,931,282	1,209,513	4,077,065	174,132	908,098
1903	146,056	1,278,108	806,638	2,948,457	179,205	649,727
1904	108,519	901,592	563,100	1,690,724	105,278	348,132
1905	257,033	1,952,407	1,120,696	3,633,879	127,170	445,095
1906	221,260	1,696,043	1,362,941	5,100,036	163,760	573,160
1907	209,021	1,793,143	1,531,882	5,653,408	103,844	259,473
1908	178,203	1,350,223	825,353	2,644,523	51,554	123,407
1909	212,765	1,405,329	(*c*)	....	(*c*)	....

(*b*) Mined in Colorado and used as flux in silver-lead smelting; not included in the statistics of consumption. The statistics of manganiferous silver ore for 1907-08 are as reported by the U. S. Geological Survey. (*c*) Figures not available.

UNITED STATES PRODUCTION AND IMPORTS OF IRON-MANGANESE ALLOYS.
(Tons of 2240 lb.)

	1906		1907		1908		1909	
	Production.	Imports.	Production.	Imports.	Production.	Imports.	Production.	Imports.
Ferromanganese	55,520	84,359	55,918	87,400	40,642	44,624	82,209	88,934
Spiegeleisen	244,980	103,267	283,430	48,995	111,376	4,579	142,831	16,921
Totals	300,500	187,626	339,348	136,395	152,018	49,203	225.040	105,855

Prices.—The following schedule of manganese-ore prices issued early in 1910 by the Carnegie Steel Company, which is the principal buyer, is for deliveries at Bessemer, Penn., near Pittsburg, or at South Chicago, to the South works of the Illinois Steel Company: For ore containing 49 per cent. or over of metallic manganese, 26c. per unit of manganese; 46 to 49 per cent., 25c.; 43 to 46 per cent., 24c.; 40 to 43 per cent., 23c. In every case, iron is paid for at 5c. per unit. For excess of phosphorus or silica over the base, deductions are made as follows: For each 1 per cent. in excess of 8 per cent. silica there shall be a deduction of 15c. per ton, fractions in proportion. For each 0.02 per cent. or fraction thereof in excess of 0.20 phosphorus there shall be a deduction of 2c. per unit of manganese per ton. Ore containing less than 40 per cent. manganese, or more than 12 per cent. silica or 0.225 per cent. phosphorus is subject to acceptance or refusal at buyer's option. Settlements are based on analysis of sample dried at 212 deg. F. The percentage of moisture in the sample as taken is deducted from the weight.

WORLD'S PRODUCTION OF MANGANESE ORE. (*a*)
(In metric tons.)

Year.	Austria-Hungary.	Belgium.	Bosnia (*b*)	Brazil. (*d*)	Canada.	Chile. *d*)	Colombia.	Cuba.	France.	Germany.	Greece.	India.
1897..........	10,043	28,372	5,344	16,054	14	23,528	8,382	.. ....	37,212	46,427	11,868	74,862
1898..........	14,219	16,440	5,320	26,417	45	20,851	11,176	....	31,935	43,354	14,097	61,469
1899..........	10,484	....	5,270	65,000	279	40,931	10,160	.. ....	39,897	61,329	17,600	88,520
1900..........	14,550	10,820	7,939	108,244	34	25,715	8,748	21,973	28,992	59,204	8,050	129,865
1901..........	12,077	8,510	6,346	100,414	447	18,480	95	25,586	22,304	56,691	14,166	122,831
1902..........	12 883	14,440	5,760	157,295	175	12,990	*Nil.*	40,048	12,536	49,812	14,960	160,311
1903..........	11,489	6,100	4,537	161,926	135	17,110	(*c*)	21,070	1,583	47,994	9,340	174,563
1904..........	15,460	485	1,114	208,260	123	2,324	(*c*)	33,152	11,254	52,886	8,549	152,601
1905..........	23,732	*Nil.*	4,129	224,377	22	1,323	(*c*)	*d*) 8,096	6,751	51,463	8,171	250,788
1906..........	20,577	120	7,651	201,500	84	35	(*c*)	*d*)13,997	11,189	52,485	(*d*)9,200	579,231
1907..........	24,954	2,100	3,500	(*c*)	1	(*c*)	(*c*)	(*c*)	18,200	74,683	10,000	916,770
1908..........	27,259	7,130	(*c*)	(*c*)	*Nil.*	1	(*c*)	(*c*)	15,865	67,692	10,750	685,135
1909..........	(*c*)	(*c*)	(*c*)	(*c*)	*Nil.*	(*c*)	(*c*)	(*c*)	(*c*)	77,177	(*c*)	(*c*)

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom	United States. (*e*)
1897........	1,634	15,448	182	1,652	403	263,115	100,566	2,749	609	161,138
1898........	3,002	11,497	220	907	68	329,276	102,228	2,358	235	190,787
1899........	4,356	11.336	137	2,049	747	659,302	104,974	2,622	422	145,548
1900........	6,014	15,831	166	1,971	77	802,236	112,897	2,651	1,384	221,714
1901........	2,181	16,270	208	904	221	522,395	60,325	2,271	1,673	649,016
1902........	2,477	10,844	*Nil.*	(*c*)	4,674	536,519	46,069	2,850	1,299	989,519
1903........	1,930	5,616	71	30	1,341	414, 334	26,194	2,244	831	671,151
1904........	2,836	4,324	199	(*c*)	843	430,090	18,732	2,297	8,880	461,854
1905........	5,384	14,017	55	(*c*)	1,541	508,635	26,020	1,992	14,582	877,482
1906........	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	1,159,948
1907........	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	1,322,861
1908........	2,750	11.130	*Nil.*	(*c*)	1,403	362,303	16,945	4,616	6,409	657 863
1909........	(*c*)	6,660	6	(*c*)	613	597,871	(*c*)	(*c*)	(*c*)	(*c*)

(*a*) From official statistics. (*b*) Includes Herzegovina. (*c*) Statistics not available. (*d*) Export returns. (*e*) Includes output of manganiferous iron ore.

Manganese Mining in the United States.

As already stated, no manganese ore was mined during 1909 in Arkansas or Georgia. The former Arkansas producers are unknown even to the post-office; the Georgia operators retain an interest in their mines, but report no activity.

California.—The Black Wonder Manganese Mining Company, of San Francisco, owns a deposit which is reported to be of great magnitude and capable of producing 10,000 tons per month. The property has not reached the producing point. The California Mining Bureau reports an output of 3 tons, worth $75, for the State during 1909.

Colorado.—Of the manganese-silver ore produced at Leadville a portion was smelted into spiegeleisen, mainly at South Chicago, Ill., and a portion was used as flux in the various smelteries of the West. Manganese, when found in the higher grade silver ores, usually warrants, and receives, a bonus on account of the better fluxing quality of the ore.

Virginia.—Many of the older producers made no output during 1909, while a few of the newer ones reported progress in development and erection of plants. Among the latter may be mentioned the Piedmont Manganese Company, of Lynchburg, which spent the year in developing its property, in process of which it accumulated several hundred tons of ore; the deposit is reported to be the largest in the county. The Midvale Mining Company, of Midvale, operated on a small scale and shipped an experimental carload. The Flat Creek Mining Company and the Evington Manganese Company operated their properties jointly, and produced a few hundred tons of manganiferous iron ore. The Dry Run mine, at Campton, owned by A. Brinkley, of Norfolk, made a small experimental shipment. The Seibel mine, at Happy Valley, maintained exploratory work and developed a deposit of considerable magnitude. The deposit is typical of the region, the ore occurring in the form of nodules and stringers scattered through a bed of clay half a mile long and 200 ft. wide. A concentrating mill with a capacity of 50 tons per day was completed in 1909, and shipments, principally to the steel mills of Pennsylvania, were begun early in 1910.

The manganese deposits of Virginia have for years afforded the principal domestic supply of high-grade manganese ores. The deposits, however, are pockety and are higher in silica and phosphorus than the Brazilian ores, but are suitable for many purposes. Deposits of manganese ore, including high-grade oxides and manganiferous iron ores, occur widely distributed throughout the State, particularly along the James river and Shenandoah valleys.

At the Crimora mine, which is one of the most important deposits, a synclinal basin in the Potsdam sandstone approximately 900 ft. long by 500 ft. wide, has been filled with the clay derived from the decomposition of the ferruginous shales overlying the sandstone. The manganese, originally disseminated through the rock, has now become concentrated in the clay resulting from its decomposition. The ore, which is psilomelane with a little pyrolusite, is found irregularly distributed through the clay in nodular masses varying from pebble size to lumps a ton or more in weight. A description of this deposit and of the method of working it was given in Vol. XIV of The Mineral Industry. The maximum thickness of the Crimora ore-bearing clay is apparently about 300 ft. The lump ore has been mostly sent to England and the fines to Pittsburg. This mine has produced up to 50 tons per day of high-grade ore, the composition of which is shown by the following analysis: Mn, 57.29; Fe, 0.37; P, 0.075 per cent.

At other points in the James river and Shenandoah valleys deposits have been opened and developed to some extent. Near Norwood, on the James river, and about two miles from Midway Mills, a deposit of high-grade manganese was opened some years ago and about 500 tons of ore of excellent quality was mined and shipped. This mine, however, was shut down on account of insufficient equipment to handle the water. The ore produced contained about 58 per cent. manganese, 1.5 per cent. iron and about 0.15 per cent. phosphorus. In the same locality, near Warminster, another deposit was opened and yielded a considerable quantity of ore similar in character to that mined at Norwood. Farther up the river, in the vicinity of Mount Athos, a deposit of good quality was mined to some extent.

At several other places on the southwest continuation of the Middle James river iron belt through Campbell and Pittsylvania counties, deposits have been opened. One of the most recent openings near Hurt station in Pittsylvania county shows indications of a considerable deposit of high-grade ore. There seem to be numerous deposits along this iron belt that are worthy of investigation. A few miles southeast from Mount Athos at Concord in Appomattox county, several openings have been made and some good ore exposed. Analyses of two samples from those openings show a manganese content of 66.6 and 52.9 per cent., respectively. Deposits are also reported in the vicinity of Willis mountain, Buckingham county, and near Spiers mountain, but only surface samples have been obtained from those localities. Undeveloped but prospected deposits have also been reported from Albemarle and Orange counties.

In the northern portion of the Shenandoah valley the manganese production has been chiefly in the form of manganiferous iron ore, though deposits of high-grade ore have been opened at a few points. In Page county, manganiferous iron ore has been mined about three miles east of Milne's station, and a promising deposit of high-grade ore, apparently of considerable extent, was found on the Garrison tract about two miles east of the railroad. The following two analyses show the character of the ore; Fine ore, Mn, 52.691 per cent.; Fe, 2.325; P, 0.324; SiO_2, 2.795; lump ore, Mn, 53.656 per cent.; Fe, 1.537; P, 0.327; SiO_2, 1.955. In Rockingham county manganiferous iron ore of quality suitable for the manufacture of spiegeleisen has been opened on Big Run creek.

In Augusta county the clays derived from the Potsdam sandstone have yielded manganese ores at several places north and southwest of Crimora. North of Crimora a deposit was opened at Grottoes yielding ore carrying 48.7 per cent. manganese, with a silica content of 6.98 per cent. and 0.40 per cent. phosphorus. A few miles northeast of Elkton an opening was made from which samples of high-grade ore were taken. Near Sherando a number of years ago several hundred tons of high-grade ore were taken out of open cuts, the results pointing to the existence of a large amount of ore in this locality. At Lyndhurst station deposits are also reported and a few miles southwest of Lyndhurst the Kennedy mines produced a considerable amount of 43-per cent. ore. At Vesuvius, in Rockbridge county, there is a deposit of rich manganese ore and at Midvale in the same county, another deposit exists from which good ore was obtained.

In Botetourt county a highly manganiferous iron ore has been extensively mined and shipped from the Houston mines, near Houston station. In places the bed contains pure manganese ore. The following analyses show the composition of the manganiferous iron ore: Mn, 24.7 per cent.; Fe, 29.1; P, 0.138; SiO_2, 7.7.

Occurrences of manganese and manganiferous iron ore are reported from the southwestern counties of the State. On Lick and Draper mountains, Wythe county, on Flat Top mountain near the Bland county line and in the mountains in the western part of Bland county, surface work has been carried on and some promising ore exposed. In Smyth county, near Marion, the Stalie's Creek Manganese Iron Company has opened a bed of high-grade psilomelane which it is developing. Many surface samples received form the southwestern portion of the State indicate the occurrence of manganese deposits over a large area, the extent and economic value of which can be determined only by further development.

Manganese Mining in Foreign Countries.

India.—The development of the manganese industry in India has been rapid and the country contests with Russia for first place among the world's producers of manganese ore. The zenith of production was reached in 1907 with an output of 902,291 long tons. In 1908, the production was 674,315 tons, the set-back being due to the general commercial depression and fall in the demand for steel. This lessened demand was not accompanied by a commensurately smaller production and in consequence there are now large stocks of manganese ore lying at the mines. Moreover the existence of these stocks closed down many of the mines during 1909 and only the larger properties near the railroads were worked. Production cannot be expected to regain its former magnitude until the accumulated stocks have been disposed of. In the accompanying table, which gives the production of the various States for a period of years, the figures represent quantities of ore mined and not of ore shipped.

PRODUCTION OF MANGANESE ORE IN INDIA. (*a*)
(In tons of 2240 lb.)

State.	1904	1905	1906	1907	1908
Baluchistan	....	....	....	15	....
Bengal	....	....	1,000	2,933	20,000
Bombay	....	640	7,520	22,821	23,232
Central India	11,564	30,251	50,073	35,743	13,315
Central Provinces	85,024	151,547	351,880	565,017	431,055
Madras	53,602	64,989	114,710	162,455	118,089
Mysore	....	....	46,312	113,307	68,624
Totals	150,190	247,427	571,495	902,291	674,315

(*a*) From *Records* of the Geological Survey of India, XXXIX.

The three great steel-producing countries, England, Germany and the United States, take a large portion of the Indian manganese ore. The exports to Holland and Belgium shown in the accompanying table were in part for transmission to Germany, and the consignments sent to Egypt were booked to Port Said for delivery at ports further west.

DISTRIBUTION OF INDIAN MANGANESE ORE EXPORTS. (*a*)
(In tons of 2240 lb.)

Year.	Belgium.	Egypt.	France.	Germany.	Holland.	United Kingdom.	United States.	Other Countries.	Total Exports.
1904	25,015	10,750	10,800	....	5,300	64,705	64,375	....	180,945
1905	54,101	3,900	29,401	....	2,400	127,856	96,835	2,200	316,694
1906	98,581	....	33,485	....	2,000	219,607	139,320	....	493,993
1907	137,999	....	51,889	552	26,252	178,348	153,380	....	548,420
1908	99,344	....	53,652	164	13,900	151,274	115,730	3,950	438,014
Total	415,040	14,650	179,227	716	49,852	741,790	569,640	6,150	1,977,066

(*a*) These figures which are taken from *Records* of the Geological Survey of India, XXXIX, do not include exports via Mormugao.

Japan.—Manganese is found in various provinces of Japan, the largest and most productive areas being Hokkaido, Aomoriken and Kyoto-fu. The most important manganese mine in the kingdom, however, is located at Owani, Mitsu province. In addition to the foregoing, the small islands of Oshima, Satsuma and Sado produce small quantities of a superior quality, the major part of their products being exported. The ore is found in the mountains near the top, close to the surface. It is transported to the seacoast or railroad in baskets carried by coolies. The greater part of the exported manganese is shipped via Suez; occasionally a cargo is sent by sailing vessels via Cape of Good Hope. American capitalists have made inquiries as to their ability to purchase or conduct mines in Japan, but the prospects do not appear flattering, owing to the rigidity of the local laws. The production in 1909 was 6660 metric tons as compared with 20,589 metric tons in 1908.

Mexico. (By Kirby Thomas.)—At Buena Vista station, between Mexico City and Cuernavaca, is a large and easily mined deposit which carries about 44 per cent. of manganese. Near La Honda in Zacatecas, on the railroad from Aguascalientes to San Luis Potosi is another deposit, from which about 700 tons have been mined for flux. The ore here runs from 45 to 50 per cent. manganese. Several deposits are known in lower California. One near Mulege is under option to British interests. The ore is in a brecciated volcanic formation and, by sorting, a high-grade product is obtainable. In Durango are small deposits of rich ore some distance from a railroad. Owing to transportation difficulties none of the Mexican manganese deposits is now working. There is practically no local consumption and the product would have to be shipped to the United States or Europe.

Russia.—Manganese mining in the Trans-Caucasus in 1909 recovered the ground it lost in 1908, but is still far behind its possibilities, owing largely to insufficient transportation facilities. In February, 1910, the Tchiaturi branch of the Trans-Caucasian railway transported 67,887 tons of manganese ore, the largest tonnage it had ever been able to handle in one month. Another retarding influence is the dispersion of the industry among a multitude of small operators. In 1908, of the 114 mines in operation, 65 per cent. of them yielded less than 1610 long tons each, or together about 36 per cent. of the total output of the district; 34 per cent. of the mines yielded between 1610 and 8050 tons each, or 46 per cent. of the total output; while only 1 per cent. of all the workings afforded more than 8050 tons each, accounting for 18 per cent. of the total production.

The following figures, compiled by the *Moniteur des Intérêts Matériels,* indicate the unstable condition of the manganese industry in the Caucasus:

STATISTICS OF MANGANESE MINING IN THE CAUCASUS.

Year.	Production, Poods.	No. of Mines.	Output per Mine, Poods.	No. of Work-men.	Output per Man, Poods.	Exports.	
						Poti, Poods.	Batoum, Poods.
1904	21,711,309	217	100,052	3,021	7,187	31,509,865	1,705,201
1905	25,876,987	202	128,104	4,285	6,039	20,464,342	1,002,152
1906	50,220,000	443	113,363	5,085	9,876	29,772,918	1,122,987
1907	40,833,000	395	103,375	4,004	10,198	31,582,275	1,948,272
1908	6,955,000	114	61,008	671	10,366	23,443,636	1,293,576

Note.—One pood=36.11 lb.

According to Customs returns, exports of manganese ore in 1909 amounted to 37,886,000 poods (609,965 long tons), valued at 7,553,000 roubles ($3,889,795), as compared with 27,270,000 poods (439,047 tons), worth 7,028,000 roubles ($3,619,420), in 1908, and 37,740,000 poods (607,614 tons), worth 9,262,000 roubles ($4,769,930), in 1907. The principal consumers of the exports in 1909 were Holland, which took 245,348 long tons (184,731 tons in 1908); Great Britain, which took 164,542 tons (133,340 tons in 1908); and Germany, which took 40,443 tons (27,853 tons in 1908). The domestic consumption of the ore, by the metallurgical plants in the center of Russia, amounted to 9636 long tons in 1908.

South Africa.—The first important shipment of manganese ore from Cape Colony occurred early in 1910, and comprised 5000 tons. This shipment was stated to be the first installment of an order for 150,000 tons from Antwerp which has to be filled within the next two years. The ore contains too much phosphorus to be acceptable in the United States. The mines are on a mountain a few miles from Cape Town.

Turkey.—The Cassandra district in the province of Salonica and the Phlinika district in Asia Minor are the two important districts producing manganese ore in Turkey. The ore occurs in both these localities in the form of pyrolusite, the Asiatic variety assaying 52 per cent. manganese. A small amount of ore assaying 83 per cent. manganese dioxide is mined at Zengan. Manganese mines are also worked in the province of Trebizond. Occurrences of manganese ores are known in the vicinity of Moudania, Seshkeui, Balia and Ushak, all in Asia Minor. In 1908, the Cassandra Mining Company exported 6850 tons of manganese ore from Stratoni.

MICA.

By E. K. Judd.

The production of mica in the United States during 1909 was obtained mainly from North Carolina, South Dakota and Georgia; Virginia, Alabama and New Hampshire contributed to a small extent. New Hampshire, which for many years was the mainstay of the mica-mining industry, has of late occupied a subordinate position and mining in that State is now carried on in a spasmodic manner. In North Carolina the industry is well established and mica mining is conducted by the larger companies in an efficient manner, although many sporadic producers still contribute small outputs. The mica deposits in the Black Hills of South Dakota, which came into prominence only a few years ago, have been systematically developed and are now operated on a large scale by the Westinghouse Electric and Manufacturing Company. Imports of mica, which in 1908 were unusually small in amount, in 1909 resumed nearly their previous volume and supplied more than half of the consumption in this country during that year.

STATISTICS OF MICA IN THE UNITED STATES.
(In pounds and tons of 2000 lb.)

Year.	Production. (a)			Imports.			
	Sheet. (b)	Scrap.		Unmanufactured.		Cut or Trimmed.	
	Pounds.	Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1897	118,852	2,882	$28,820	722,939	$161,334	226,771	$41,068
1898	110,918	3,529	39,837	877,930	115,930	78,567	34,152
1899	97,586	6,917	50,596	1,709,839	233,446	67,293	42,538
1900	127,241	5,417	42,889	1,892,000	290,872	64,391	28,688
1901	360,600	2,171	19,719	1,598,722	299,065	78,843	35,989
1902	373,266	1,400	35,006	2,149,557	419,362	102,299	46,970
1903	619,600	1,659	25,040	1,355,375	288,783	67,680	29,186
1904	668,358	1,096	10,854	1,085,343	241,051	61,986	22,663
1905	851,800	856	15,255	1,506,382	352,475	88,188	51,281
1906	1,423,100	1,489	22,742	2,984,719	983,981	82,019	58,627
1907	1,060,182	3,025	42,800	2,227,460	838,098	112,230	77,161
1908	972,964	2,417	33,904	497,332	224,455	51,040	41,601
1909	888,000	2,670	37,400	1,618,831	509,220	168,169	84,990

(a) Statistics for 1901 to 1908 inclusive are those of the U. S. Geological Survey. (b) The value of sheet mica being so widely variable, and so little indicative of commercial results, and all previous statistics being of doubtful accuracy, they have been omitted from this table.

Mica Mining in the United States.

Georgia.—Pegmatite veins, similar in nature and occurrence to those from which mica is obtained in North Carolina, are found in Lumpkin, Fannin and other counties in the northwest corner of Georgia. The principal operator is the Pitner Mining Company, of Gaddistown, which during 1908 and 1909 developed a group of 10 or more mica mines 6 to 10 miles northwest of Dahlonega. Most of this company's mines yield light-colored mica, though the usual proportions of ruled and wedge mica are also found. The company reported a substantial output of sheet, scrap and pulverized mica during 1909. Other occurrences of mica in Georgia have been explored by B. E. Dyer, of Tower, Union county, J. A. Hinson, of Hinson, Fla., whose property is situated near Marietta, Ga., and the Dozier Mining Company, of Atlanta, which will probably develop the Chapman mica mine near Elberton.

North Carolina.—The largest mica miners in this State are the Asheville Mica Company, the Great Southern Mica Company, both of Asheville, and D. T. Vance, of Plumtree. These three operators supply about half the entire output of the State, most of the remainder coming from numerous small mines and prospects scattered through the mountain districts in Ashe, Mitchell, Yancey, Haywood, Jackson, Transylvania and Macon counties. A few of the mica mines in North Carolina are equipped with modern machinery, but none of them is operated by methods comparable with those employed in South Dakota and Canada. The recently incorporated Sterling Mica Company, of Franklin, owns two mines in Macon county, and will erect a plant for preparing and grinding its product. The plant of the Carolina Mica and Milling Company at Penland was enlarged and improved in 1909.

The majority of the mica produced in North Carolina is of a light rum color. The better grades are of excellent quality, and suited for glazing, while large amounts of the less perfect mica are consumed in the electrical industries. As a hint to any concerns who may contemplate the operation of mica mines the output of which is suitable only for pulverizing, it may be stated that the larger operators in North Carolina produce and market about 10 ℔. of scrap mica, suitable only for grinding, for every pound of trimmed sheet mica.

South Dakota.—The best mica deposits yet developed in this State lie near Custer, in the Black Hills, and two of them are extensively operated by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Penn. The mica is of light color and averages somewhat softer than that of similar grade produced in North Carolina. The Westinghouse company's No. 1 or New York mine has been systematically developed to a depth of over 200 ft. The pegmatite vein averages 5½ ft. wide, and yields about 1090 ℔. of rough mica to each 100 cu. ft. of vein material, or about 6.6 per cent. of the total vein matter. The mica is most commonly found in crystals 2 to 8 in. across and 1 to 5 in. thick, which seem to have a tendency to lie perpendicular to the walls of the vein. Crystals 12 in. across are not rare, and larger ones have been found. The Westinghouse company consumes its entire output of sheet mica. The mine product is rough trimmed and the resulting scrap is pulverized on the ground. The sheet mica is then shipped to a better equipped factory at Lincoln, Neb., where it is further trimmed, punched and graded before being sent to East Pittsburg. The scrap from the Lincoln factory is sold to other concerns for grinding.

Mica Mining in Foreign Countries.

Brazil.—Marketable mica is found in pegmatite veins in many parts of Brazil, and is sold locally to German concerns at very low prices. Operations have never been conducted extensively, for lack of talent and capital. Most of the samples that pass through Rio de Janeiro are large, clear crystals, though stained with iron because secured from weathered outcrops. Some remarkable specimens have come from the far interior, and all samples indicate a probable improvement in quality if the workings were carried deeper.

Canada.—The productive mica mines of Canada are situated to the north of Ottawa in Buckingham, Templeton, Hull and Wakefield townships, Quebec province, and in neighboring townships in western Ontario. The majority of the mica from these mines is exported to the United States, though shipments to Great Britain in competition with Indian mica are steadily increasing. The value of the mica produced annually in Canada, the value of the total amount exported and the value of the

STATISTICS OF MICA IN CANADA.

Year.	Production.	Total Exports.	Exports to U. S. (*a*)	Year.	Production.	Total Exports.	Exports to U. S. (*a*)
1900..........	$166,000	$146,750	$136,981	1905..........	$178,235	$179,049	$121,560
1901..........	160,000	152,553	161,741	1906..........	303,913	581,919	328,991
1902..........	135,904	391,812	184,287	1907..........	312,599	422,172	596,321
1903..........	177,857	196,020	196,470	1908..........	139,871	198,839	(*b*) 140,166
1904..........	160,777	198,482	137,191	1909..........	154,106	256,834	(*b*) 137,383

(*a*) Fiscal year ending June 30. (*b*) Fiscal year ending March 31.

portion exported to the United States are stated in the following table. Owing to the great disparity in the quality and unit value of the various mica products, statistics of tonnage are of little value. The excess in the value of exports over that of production is due to the increase in the value of the product by treatment, transportation, etc.

In Ontario the principal producers were the Loughborough Mining Company, whose output is utilized by the General Electric Company, and the Dominion Improvement and Development Company. The mines of these companies are in Frontenac and Perth counties. Besides these, Kent Bros., of Kingston; W. L. McLaren, Perth; J. M. Stoness, and J. P. Tett & Bros., Bedford Mills, contributed to the output. Practically all of the mica from Ontario and Quebec is of the amber variety and is well adapted for use as an insulating material in the manufacture of electric machinery. Much of the small material which in former years was consigned to the dump or was sold as scrap, is now worked up into micanite, in which pieces of mica of a variety of sizes are by pressure and the use of shellac consolidated into boards or sheets of suitable form and dimensions.

In British Columbia there are considerable deposits of mica in the Big Bend district, at an elevation of 7000 to 8000 ft. The bands of mica schists are described as containing segregations of quartz from 4 to 100 ft. in width and these carry sheets of mica up to 2 ft. in diameter. Near the surface the mica crystals are iron stained, but below the zone of weathering, bright and clear. Mica crystals were found by a recent exploring party over a distance of 2½ miles. Other fine specimens have been obtained near Tete Juan Cache, north of Revelstoke.

India.—In 1908 the production of mica in India amounted to 2677 long tons. The output was derived from the States of Bengal, Madras and Rajputana which contributed 1803, 562 and 312 tons respectively. In Bengal the principal mines are in the districts of Hazaribagh, Gaya and Monghyr; in Madras, the output is chiefly from the Mellore district; in Rajputana, Ajmere and Merwara contribute the bulk of the production. Exports of mica during 1908 were 27,572 cwt. valued at £139,515. Over 60 per cent. of the exports were to the United Kingdom. About 400 tons of the poorer grades of mica and a small quantity of the largest sheets are used annually in India for ornamental and decorative purposes.

PRODUCTION OF MICA IN INDIA.
(In metric tons.)

1900	1,025	1903	1,002	1906	2,463
1901	1,505	1904	828	1907	2,652
1902	806	1905	1,174	1908	2,720

The London Mica Market During 1909.

The demand for mica during 1909 showed a satisfactory increase. As regards supplies Calcutta took the lead. The returns from Madras the principal mines, due to legal complications. The development of were somewhat less satisfactory, owing to curtailment in the output of mica deposits in German East Africa were of importance, but it remains to be proved whether the product from this district can successfully compete with Indian mica. A decided improvement in trade with a gradual return to higher prices is anticipated for 1910. At Calcutta the demand for block mica varied somewhat, but at the close of the year a firm tendency existed. Supplies remained about normal. At Madras steady business was maintained throughout the year, but stocks of the small sizes accumulated with resulting lower prices. No. 5 grade of splittings was somewhat neglected, but closed firm, while supplies of No. 6 were readily absorbed throughout the year. Higher prices are anticipated in the near future for both grades of splittings as stocks are very small. During 1909, arrivals of mica in London amounted to 1,992,900 ℔., and deliveries of 2,187,800 ℔. were made. Total stocks on hand Dec. 31, 1909, were estimated at 1,017,400 ℔. Ceylon, Canada, South America and East Africa contributed supplies, most of which were disposed of at somewhat irregular prices.

Uses.

The principal use for mica is in the manufacture of electric apparatus; formerly its application in stove manufacture consumed the bulk of the production. The glazing industry still consumes much of the finest grades of sheet mica in the manufacture of windows for stoves, lamp chimneys, and in many minor uses. The use of mica as an insulating material in electrical apparatus and machinery is extensive. Many forms of dynamos, motors, induction apparatus using high voltage, switchboards, lamp sockets, etc., have sheet mica in their construction. For practically every purpose of electrical insulation, with the exception of commutators of dynamos and motors, the mica produced in the United States is as satisfactory as any other. For insulation between the copper bars of commutator segments, however, no mica produced in this country is as satisfactory as the "amber" or phlogopite mined in Canada and Ceylon. This is due to the fact that the amber mica wears down evenly with the copper segments, while the ordinary white or muscovite mica, through its greater hardness, does not wear down so rapidly and is left in ridges above the copper, causing the motor to spark. Much of the sheet mica used in electric apparatus is first made up into large sheets of mica board or micanite. In this form it is available for use in most of the purposes for which ordinary sheet mica can be used. It can be bent, rolled, cut, punched, etc. Bending is accomplished during baking, or by heating to soften the shellac used in the manufacture of the mica board. Insulation for commutators is generally cut from "amber" mica board.

Scrap mica, or mica too small to cut into sheets, and the waste from the manufacture of sheet mica are used in large quantities commercially. The greater part is ground for the manufacture of wall papers, lubricants, fancy paints, molded mica for electrical insulation, etc. Ground mica applied to wall papers gives them a silver luster. When mixed with grease or oils mica forms an excellent lubricant for axles and bearings. Mixed with shellac or special compositions, ground mica can be molded into desired forms, and is used in insulators for wires carrying high potential currents. Ground mica for use in molded form for insulation purposes should be free from metallic minerals. For lubrication it is necessary that gritty matter be eliminated, either after grinding or by using only pure mica for grinding. For wall papers and brocade paints a ground mica with a high luster is required. This is best obtained by using a clean light-colored mica and grinding under water. Coarsely ground or bran mica is used to coat the surface of composition roofing material. The mica serves to keep the material from sticking when rolled for shipping or storage, as well as to increase the resistance of the roofing to the weather.

Bibliography.

Anonymous. "Preparation of Mica Powder." (*Bull.* Imp. Inst., Vol. VII, No. 1, 1909; 4 pp.)

Atkinson, A. S. "Mica Mining." (*Eng. and Min. Journ.*, May 8, 1909; 1¼ pp.)

Sterrett, D. B. "Mica Deposits of South Dakota." *Bull.* 380, U. S. Geol. Surv., 1909; 15½ pp.)

MINERAL WOOL.

The production of mineral wool in the United States in 1909 amounted to 11,626 short tons, worth $101,621, an increase of 2429 tons and $24,393 in value over the preceding year. Of the total 1909 output 3952 tons, valued at $36,723, were slag wool, and 7674 tons, valued at $64,898 were rock wool. As compared with the corresponding figures for the preceding year, the output of slag wool showed an increase of only 47 tons, while the production of rock wool increased by 2382 tons. In 1909, the average price of slag wool at the factories was $9.30 per ton, and of rock wool, $8.35 per ton.

PRODUCTION OF MINERAL WOOL IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Amount.	Value.	Per Ton.	Year.	Amount.	Value.	Per Ton.
1898	6,560	$70,314	$10.72	1904	(a)	....	....
1899	7,448	85,899	11.53	1905	6,164	$69,560	$11.28
1900	6,002	60,320	10.05	1906	5,375	55,550	10.33
1901	6,272	68,992	11.00	1907	9,008	81,769	9.08
1902	10,843	105,814	9.67	1908	9,197	77,228	8.40
1903	(a)	....	....	1909	11,626	101,621	8.74

(a) No statistics collected.

The following concerns are the principal manufacturers of mineral wool: United States Mineral Wool Company, 140 Cedar street, New York; Pennsylvania Mineral Wool Company, Norristown, Penn.; Banner Rock Products Company, Alexandria, Ind.; Hoosier Rock Wool Company, Alexandria, Ind.; Union Fibre Company, Yorktown, Ind.; Columbia Mineral Wool Company, 112 Clarke street, Chicago, Ill.

A process for waterproofing mineral wool was patented by T. B. Parkinson, of Muncie, Ind. (U. S. Pat. No. 945,583, Jan. 4, 1910), and assigned to the Union Fibre Company. The molten slag, as it emerges from the cupola and comes into contact with the air or steam blast, is subjected to the action of a vaporized hydrocarbon oil. The oil is allowed to fall in a thin stream directly upon the molten slag before it enters the blow-tube. In this way each individual filament of the wool becomes coated with the products of combustion, and a waterproof material is obtained.

MOLYBDENUM.

The commercial ores of molybdenum are the sulphide, molybdenite (MoS_2), containing 60 per cent. molybdenum; the molybdate of lead wulfenite ($PbMoO_4$), which sometimes contains copper and other injurious metals in such amounts as to render it unsuitable for the extraction of pure molybdenum; and the oxide, molybdite (MoO_3), an earthy mineral containing, when pure, 66 per cent. of molybdenum. Molybdenite is the most reliable source of the metal.

Molybdenum is chiefly useful as a hardener in special steels, its properties in this direction being similar to those of tungsten, but two or three times more pronounced. The consumption of molybdenum in the steel industry has not maintained the growth that was first predicted, mainly for three reasons; (1) uncertainty as to the volume and quality of the available ores; (2) metallurgical difficulties in the extraction of the pure metal from these ores; (3) more rapid advance in the use of tungsten in this field, due to its more plentiful and suitable ores from which the metal can be extracted with much less difficulty and expense than in the case of molybdenum. The amount of molybdenum ore required by the chemical industry for the preparation of ammonium molybdate and other salts is small and seems to be abundantly provided by the mines already in operation. Any increase in demand for molybdenum ores therefore depends upon the more extensive employment of molybdenum in steel.

Market.—The market for molybdenum ores is very narrow. The price fluctuates widely and is generally subject to special negotiation at each particular sale. American buyers require concentrates to contain 90 to 95 per cent. molybdenite, for which they will pay $400 to $450 per ton. The principal purchasers in the United States are: Electrometallurgical Company of America, New York; Primos Chemical Company, Primos, Penn.; DeGolia & Atkins, San Francisco, Cal. In Germany, Friedrich Krupp of Essen is a large user of molybdenum.

Molybdenum Mining in the United States.

Deposits of molybdenite are of common occurrence throughout the United States. Commercial supplies of the ore have thus far come only from Arizona, but promising developments have been made in Maine, Oregon and Washington.

Arizona.—The following notes on the molybdenite deposits of Arizona are abstracted from a report by F. C. Schrader and J. M. Hill,[1] which describes a number of occurrences in the southern part of the State, in the Santa Rita and Patagonia mountains. The productive, or promising localities are: Helvetia, Madera cañon, Providencia cañon, Duquesne, and San Antonio cañon. The prevailing country rock is granite, and the molybdenite is found in or adjacent to quartz veins or aplite dikes. The molybdenite is closely associated with chalcopyrite in some of the mines, and with mica in others. In a few veins it occurs comparatively free from sulphides. Chalcopyrite is the most objectionable associate because of the difficulty in separating the two minerals, and because more than a trace of copper renders molybdenite unsuitable for metallurgical purposes. The owners of mines and prospects in which molybdenite has been developed in this district are as follows: Helvetia Copper Company, C. B. Ridley and Mr. McCleary, all of Helvetia, Capt. O'Connor and D. Coughlin, of Duquesne, and the Banco Del Oro Mining Company, Magdalena, Sonora, Mexico. The authors of the report consider that the Leader mine, owned by the Helvetia Copper Company, affords the best outlook for the exploitation of molybdenite ore. The Mammoth and Troy copper mines, in Pinal county, have for several years yielded an output of wulfenite, picked from old dumps. A concentrating plant for extracting this mineral from the crude ore, of which it constitutes 1 to 3 per cent., was erected, and an intermittent production has been maintained.

Maine.—The molybdenite deposits at Cooper, Washington county, have been the scene of considerable development. The property is owned by the American Molybdenum Company, of Boston, which has erected a mill for the concentration of the ore. Another deposit on Catherine hill, at Tunk pond, Hancock county, is described by B. W. Hills.[2] The country rock is granite, and the molybdenite occurs in and adjacent to pegmatite dikes. That contained in the dikes is usually free from other sulphides, while the disseminated molybdenite in the granite walls is commonly associated with pyrite and chalcopyrite. The mineral-bearing zone appears to be several hundred feet wide and three-quarters of a mile long. Some quarrying has been done at the eastern end of the deposit. Mr. Hills is of the opinion that conditions are favorable for cheap operation.

Nevada.—Wulfenite is of common occurrence in many mines in this State. Molybdenite is found in a wide quartz vein in Lida valley, Esmeralda county.

[1] *Bull.* 430-D, U. S. Geological Survey.
[2] *Min. World*, Aug. 7, 1909.

Oregon.—A number of molybdenite occurrences have been noted and partially developed near Galice, Josephine county. None of them has arrived at the productive stage, owing chiefly to unsolved difficulties in concentrating the ore.

Molybdenum Mining in Foreign Countries. (*a*)

Canada.—Although ores of molybdenum are found in many localities, little is known as to the value of the deposits. Ontario is the only province in which the ore has been mined to any extent. A deposit has been worked at Sheffield, Addington county, since 1903. The mineral occurs there with pyrites in a granite country rock, and as mined, contains about 4 per cent. of molybdenum. In 1909 deposits of molybdenite were found at Turnback lake in the eastern Abitibi district, northern Ontario, about three miles from the Grand Trunk Pacific railway. Veins were reported carrying 400 lb. of molybdenite to the ton, with traces of gold. On Kewagama lake, a few miles to the southeast, there are seven or eight square miles of granite outcroppings in which this mineral has been found to occur frequently. On the east shore of the lake the granite is cut by quartz veins containing molybdenite in large crystals, and it has also been found on the hills back from the lake but in lesser quantities.

Germany.—A small quantity of molybdenum ore is obtained from deposits on the Saxon side of the Erzgebirge, where it occurs in quartz and a hard greenish marl.

Japan.—Deposits of molybdenite are said to occur in the provinces of Echigo, Izomo and Hioa, and small quantities of the mineral have been exported, principally to the United States.

Mexico.—Wulfenite is found abundantly with the lead ores of the Cuchillo Parado mine in eastern Chihuahua. Some shipments have been made. Molybdenite is reported in several Sonora localities, and in the states of Oaxaca, Hidalgo and Jalisco. An American company has acquired a deposit near Pozos, Sonora.

Natal.—Outcrops showing molybdenum ore occur at Impendhle, at the foot of the Mahotoya range, Hlatimba river. The ore is said to occur as an oxide impregnation in sandstone beds, which outcrop over an irregular area, the greatest length of which is three miles. The material is reported to carry at least 8 per cent. of molybdenum, and another rare element, probably uranium, is present. Five bore holes have been sunk on this deposit and there is said to be an abundance of ore.

(*a*) Most of the data under this heading was obtained from *Bull.* Imp. Inst., VI, No. 2.

New South Wales.—The greater quantity of the molybdenite produced is obtained from the Kingsgate mines, near Glen Innes, where it occurs, together with bismuth, in quartz pipes of approximately cylindrical shape, which vary from 10 to 50 ft. in diameter. An occurrence at Whipstick, near Pambula, is similar to the above. Molybdenite is rather common in the New England tin districts, especially at the Elsemore and Newstead mines, where it occurs in the tin veins which traverse the granite. The ore is also known to occur at Bullen Flat, Argyle county; Kiandra, Wallace county; Cleveland bay, and many other localities. In 1909, 28 tons of molybdenite, valued at £3249, were exported.

New Zealand.—Molybdenite was discovered in 1898 at the Iron Cap mine at Tarauru, Thames, where it occurs in pockets and small stringers near an ironstone vein. Individual fragments carry about 40 per cent. of molybdenum, but further prospecting is necessary to prove the value of this deposit. The ore also occurs on Dusky sound on the west coast of Otago and in auriferous quartz in the Paparoa range. Molybdenite has been found recently in connection with a copper deposit at Mount Radiant, at the head waters of the Mokihinui and Little Wanganni rivers. The mineral occurs in quartz and feldspar veins, which also carry chalcopyrite and iron pyrites. More development is necessary to determine the commercial possibilities of this deposit. Wulfenite is known to occur in Dun mountain, Nelson.

Norway.—The deposits at Flekkefjord are being exploited by a British company. Wulfenite has been mined near Egersund, and has also been found in a hornblende gneiss, associated with the copper ores, which occur on the south coast in the neighborhood of Arendal and in the valley of Numedal.

Peru.—Molybdenite has been found in the provinces of Convención, Huaylas, Canta, Trujillo, Carabaya, Ica and Aymaráes, but the most important discovery was made in 1901 in the province of Jauja, on the Runatullo farm, giving rise to the formation of the "Sociedad Explotadora de Molibdeno," organized in Lima. Wulfenite was found by A. Raimondi, with malachite and other copper ores, in some mines near Huantajaya, province of Tarapacá.

Queensland.—In 1909 the production of molybdenite in Queensland amounted to 92 tons, valued at £9272. Almost the entire production was obtained from Bamford, Wolfram, and Wolfram camp in the Chilligoe district, where the molybdenite occurs in connection with tungsten ores. The major part of the output was obtained by hand-picking the wolframite dumps. Ollera creek in the Townsfield district produced 2¼ tons of molybdenite in 1909.

South Australia.—Here molybdenite is worked at North Yelta as a by-product of copper mining; an ore containing 95 per cent. of the mineral is produced from the copper lode in which it occurs in small but uniform quantities.

Sweden.—In the island of Ekholmen in the archipelago of Westervik, molybdenite has been worked in a hornblende gneiss, associated with molybdite and copper pyrites. The veins carrying the minerals vary from 6 in. to 2 ft. thick, and have yielded lumps of pure molybdenite weighing up to 5 pounds.

West Indies.—A sample of molybdenite from the Virgin Islands, taken from an old tailing heap, gave: Mo, 48.93 per cent.; Fe, 3.32; S, 32.20 and SiO_2, 1215. Ore of this quality would be marketable under present conditions, but nothing is known as to the quantity of this product available.

Technology of Molybdenum.

Extraction of Molybdenum from its Ores.—There are two methods in general use for the reduction of the ore: The aluminothermic process yields a product free from carbon, but containing small quantities of silicon and from 1 to 2 per cent. of iron. Alloys with chromium and nickel are also made by this process. The electrical process consists in heating the ore in a carbon tube, employing a current of 350 amp. at 60 volts, when a portion of the sulphur is evolved as sulphur dioxide. On increasing the current to 900 amp. at 50 volts, complete fusion is obtained, and the rest of the sulphur is expelled. The metal produced in this way contains about 7 per cent. of carbon, of which about 1 per cent. is graphitic. The whole of this carbon can be removed by heating the crude metal with molybdic oxide.

Uses.—The general effect of the addition of molybdenum to steel, up to 4 per cent., may be said to be to increase the hardness, toughness and elongation without the production of any deteriorating effect when the steel is heated or welded. The use of this element in steel manufacture is largely in its experimental stage, and opinions differ as to the value of the alloy in comparison with tungsten steel. Molybdenum is stated to be about three times as powerful in its action as tungsten. Tool steels may contain from 2 to 4 per cent. molybdenum, and an alloy containing 3 per cent. is stated to be particularly suitable for the manufacture of armor plates. Molybdenum steel at high temperature becomes very hard, but when annealed is softer than tungsten steel. It can be tempered in water without showing fissures, and it is said not to break cold short so easily as does tungsten steel. The molybdenum employed in steel works is usually in one of three forms; (1) a dark-blue metallic powder containing 95 to 99 per cent. of molybdenum; (2) ferro-molybdenum, of which typical specimens contain molybdenum 87.5, iron 6.4, carbon 6.3 per cent.; and molybdenum 75.8 with less than 2 per cent. of carbon, and the rest iron; (3) molybdenum-nickel, containing 75 per cent. molybdenum and 25 per cent. nickel. An alloy with chromium is also made containing 50 per cent. of molybdenum and chromium.

The ammonium salt of molybdic acid is employed in chemical analysis as a reagent for the estimation of phosphoric acid; several tons per year are used for this purpose in the United States alone. It is also used as a fire-proofing material and as a disinfectant. Molybdenum salts give a fine blue color to pottery glazes, and at one time were employed, to a small extent, in the preparation of pigments for textile fabrics. It is possible to employ certain salts of the metal in conjunction with logwood to impart a deep yellow color to leather. Molybdenum indigo is used as a pigment for coloring rubber.

Molybdenum Arc-lamp Electrodes.—Molybdenum as a material for arc-lamp electrodes is the basis of two patents granted June 14, 1910, to George A. Thomson. The inventor states that by the use of a metallic electrode containing molybdic material, an arc of great brillliancy can be produced and that the light from such arc will be white and of maximum volume. The molybdic material may be in the form of metallic molybdenum, associated with a material having greater electrical conductivity than metallic molybdenum. The molybdenum oxide may be in comminuted form and held together by suitable binding material, and other material (such as metallic iron) will preferably be added to increase the conductivity of the electrode. It is said that excellent results have been attained with the use of an electrode containing as much as 86 per cent. metallic molybdenum. It has also been found that an arc of large volume and great brilliancy giving white light can be produced with the use of an electrode employing concentrates made from molybdenum ore containing approximately 15 per cent. oxide of molybdenum, fine concentrates being enclosed within an iron tube. An arc of great volume and brilliancy with white light can be produced with the use of a ferro-molybdenum electrode containing approximately 10 per cent. of metallic molybdenum and 90 per cent. metallic iron.

MONAZITE.

Monazite, which is the only commercial source of the thorium nitrate used for the manufacture of incandescent gas mantles, is mined in the United States only in North and South Carolina. The mineral is not of uncommon occurrence elsewhere in the country, and promising developments have been carried on at Centerville, Idaho. Brazil furnishes the bulk of the world's production, the output from that country being shipped mainly to Germany, where it is converted into thorium nitrate. About 25 or 30 tons of thorium nitrate are imported annually into the United States. The declining price of the salt in the German market during recent years has stimulated imports into the United States, with an accompanying falling off in the production of monazite in this country. Monazite is seldom imported, because it is now cheaper to buy the German nitrate. In former years the domestic production of thorium nitrate from Carolina monazite supplied half or more of the consumption of the salt in this country.

MONAZITE PRODUCTION IN THE UNITED STATES.
(In pounds.)

Year.	United States. (*a*)			North Carolina. (*b*)		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1897	44,000	$ 1,980	$0.045	44,000	$ 1,980	$0.045
1898	250,776	13,542	0.054	250,776	13,542	0.054
1899	350,000	20,000	0.057	350,000	20,000	0.057
1900	908,000	48,805	0.054	908,000	48,805	0.054
1901	748,736	59,262	0.079	748,736	59,262	0.079
1902	802,000	64,160	0.080	802,000	64,160	0.080
1903	862,000	64,630	0.075	773,000	58,694	0.076
1904	745,999	85,038	0.114	685,999	79,438	0.116
1905	1,352,418	163,908	0.121	894,368	107,324	0.120
1906	846,175	152,312	0.180	697,275	125,510	0.180
1907	547,948	65,754	0.120	(*c*)456,863	54,824	0.120
1908	422,646	50,718	0.120	(*c*)310,196	37,224	0.120
1909	541,931	65,032	0.120	(*c*)391,068	46,928	0.120

(*a*) Statistics of the United States are those of the U. S. Geological Survey. (*b*) The figures for North Carolina, from 1897 to 1906, inclusive, are from "The Mineral Industry of North Carolina." (*c*) The figures for 1907, 1908 and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.

Monazite in the United States.

The Carolinas.—The most productive Carolina localities are situated in Rutherford and Cleveland counties of North Carolina, and Greenville and Cherokee counties of South Carolina. The monazite occurs as sand in alluvial gravel deposits along the beds, banks and terraces of streams. These deposits range from one to several feet thick and up to several acres in area. They probably rarely contain more than 1 per cent. of monazite. The customary method of working the deposits is to concentrate the sand in sluices or on shaking tables, yielding a product containing anywhere from 15 to 70 per cent. monazite. This is generally delivered to centrally located mills equipped with magnetic separators, by means of which the monazite content is raised to about 90 per cent. (equivalent to 4½ or 5 per cent. of thoria), in which form it is shipped to the chemical works.

Idaho.—Monazite is widely distributed through the granite areas of this State. Day and Richards[1] list 37 localities in Idaho from which samples of heavy sands containing monazite were procured. Commercial developments have progressed at Centerville, Boise county, where the Centerville Mining and Milling Company, of Chicago, during 1908 dug a nine-mile ditch and erected a mill containing one Pinder and two Wilfley tables, magnetic separator, etc., in readiness for operation during 1909. The manager reports that the final concentrate from experimental runs contains 97 per cent. monazite, carrying 5 per cent. thoria.

Another locality on Musselshell creek in southeast Nez Perce county is described by F. C. Schrader.[2] The locality is 28 miles east of Greer, on the Clearwater branch of the Northern Pacific Railway. Monazite is found in the residual detritus of the surrounding granite, and more largely in the alluvial gravels in the bottom of the valley, being richest close to bed rock. The same gravels carry gold, and extensive hydraulic operations have been conducted for many years. The principal operator now is the Musselshell Mining Company, at Musselshell Falls, near the center of the field. Eleven samples of heavy sands from scattered points along the valley averaged 29 per cent. of monazite and when cleaned to 90 per cent. their thoria content was raised to about 3 per cent. At present prices, these deposits could not be worked profitably for monazite alone, but the material could probably be collected at small expense as a by-product of gold washing. The Oro Grande Placer Mining Company, at Pierce, Nez Perce county, reports that similar, but richer, deposits are found at Pierce.

Monazite in Brazil.

The Bahia and Espirito Santo deposits continue to be worked by holders of concessions who ship their product to Hamburg, where it is bought on the basis of its thorium content. Monazite sand from the inte-

[1] *Mineral Resources of the United States*, 1905, pp. 1180-1227.
[2] U. S. Geological Survey, *Bull.* 430-D, p. 36.

rior of Brazil contains from 4 to 5.7 per cent. of thorium oxide, while that from the sea coast may contain as much as 7 per cent. It has been found in commercial quantities in alluvial deposits in the States of Rio de Janeiro and Minas Geraes and along the coast, from Rio to Bahia. Its original occurrence is in certain felspathic rocks, pegmatite, syenite, and gneiss, in which it constitutes from 0.07 to 0.2 per cent. of the weight. The present deposits have been derived by erosion and concentration of such rocks. The interior deposits are found in the beds of dry water courses in the form of gravel and sand containing not more than 2 per cent. monazite, together with quartz, garnet, ilmenite and other heavy minerals. The deposits sometimes lie on the surface, and sometimes under a bed of clay, as much as 3 m. thick. The sand is mined and concentrated roughly, and is finished on electro-magnetic machines, which make a 95 to 96-per cent. monazite product containing, on the average, 3.7 per cent. thorium oxide.

The early development of the beach deposits by Gordon, and the subsequent retraction of his concession by the Brazilian government, which had not been aware of the value of the deposits as a source of revenue, is well known. The government has even considered the possibility of establishing a chemical manufacturing industry for the preparation of thorium nitrate within its own boundaries, and it is reported that the State of Santo has granted a mining concession to Israelsohn & Co., with this object in view. The British Consul at Bahia reports that exports of monazite sand from that city during recent years have been as follows in metric tons: 1904, 2901; 1905, 1039; 1906, 945; 1907, 1741; 1908, 2114. The annual output of beach sands depends a good deal upon the state of the weather.

Determination of Thorium in Monazite.

According to V. Borelli[1] about 2 gm. of finely powdered monazite are treated in a platinum crucible with 5 c.c. of sulphuric acid of sp.gr. 1.84 and a few c.c. of hydrofluoric acid; the crucible is fixed in a larger porcelain crucible by means of a ring of asbestos, and is heated gradually so that the hydrofluoric acid is evaporated in 1 to 2 hours and the sulphuric acid in 4 to 5 hours. When fumes are no longer evolved, the platinum crucible is allowed to cool, the greater part of the contents detached with a spatula and dissolved in about 10 c.c. of hydrochloric acid (1:1). After diluting with water to 50 or 60 c.c., the solution is decanted through a filter. The crucible is now half filled with hydrochloric acid (2:1), heated for a few minutes on the water-bath, the contents poured into a basin, the residue again digested with hydrochloric

[1] *Gaz. Chim. Ital.*, XXXIX 425-448.

acid and then the crucible carefully washed out, the whole of the contents being received in the basin. The contents of the latter are heated for 15 min. on a boiling water-bath, diluted with water, the solution decanted through the same filter as used previously, the residue digested with concentrated hydrochloric acid, and the sequence of operations repeated three or four times until only a small quantity of a greyish-white, sandy residue, insoluble in dilute acid, is left. The solution (about 300 c.c.) is heated to boiling, treated with ammonia until the greater part of the acid is neutralized, i.e., until the precipitate formed redissolves only with difficulty, and then to the boiling solution, crystallized ammonium oxalate is added in small quantities at a time, until the precipitation of the rare earth oxalates is complete. After a few hours, the solution is decanted through a filter, and the precipitate washed by decantation and on the filter with a dilute solution of ammonium nitrate. The precipitate is taken up with 15 to 20 c.c. of nitric acid (1:1), heated to boiling, and potassium permanganate solution added till a pink color persists. The solution is boiled to destroy the excess of permanganate, ammonia added until the solution is neutral or just faintly acid to litmus, and then 10 c.c. of a 3-per cent. solution of pure hydrogen peroxide added, and the whole heated for a few minutes at 60 to 80 deg. C. The precipitate of thorium peroxide, colored a more or less intense orange by cerium peroxide, is filtered off, and washed with a dilute solution of ammonium nitrate. The thorium peroxide is freed from the 5 to 8 per cent. of impurities it contains by redissolving in nitric acid and reprecipitating with hydrogen peroxide. It is then again washed with ammonium nitrate solution ignited in a platinum crucible, and weighed.

NATURAL GAS.

Notwithstanding the decrease in the output of natural gas in the leading producing States, Pennsylvania, Ohio, Indiana and West Virginia, where the supply in many districts is nearly exhausted, the total production of the country continues to increase. The advance is due to the rapid development of the Gulf and mid-continental fields, which has practically only begun, and to the extension of the known gas-bearing areas in the Appalachian field. Conditions in the industry are changing rapidly, and whereas a few years ago almost the entire output of natural gas was utilized for industrial purposes at or near the place of production, today it is piped for long distances, being delivered from West Virginia to points as distant as Cleveland, Ohio. Its employment in manufacturing industries is rapidly declining and is being supplanted by its use for domestic purposes. The building of extensive pipe systems has resulted in raising the price of gas and in many instances it is no longer a particularly cheap fuel.

PRODUCTION OF NATURAL GAS IN THE UNITED STATES IN 1907 AND 1908. (*a*)

State.	1907			1908		
	Quantity, M. cubic feet.	Cents per M. cu. ft.	Value.	Quantity, M. cubic feet.	Cents per M. cu. ft.	Value.
Pennsylvania	135,516.015	13.9	$18,844,156	130,476,237	14.64	$19,104,944
West Virginia	122,687,236	13.6	16,670,962	112,181,278	13.23	14,837,130
Ohio	52,040,996	16.8	8,718,562	47,442,393	17.38	8,244,835
Kansas	76,707,165	8.1	6,198,583	80,740,264	9.52	7,691,587
Indiana	6,624,204	23.7	1,572,605	5,255,792	24.97	1,312,507
New York	3,287,974	23.3	766,157	3,842,402	24.97	959,280
Oklahoma	4,867,031	8.5	417,221	11,924,574	7.21	860,159
Kentucky	1,303,158	29,2	380,176	1,430,062	29.7	424,271
Alabama, Louisiana, Texas	1,287,734	13.8	178,276	1,752,372	13.5	236,837
California	230,344	73.1	168,397	478,698	64.3	307,652
Illinois	1,154,344	12.4	143,577	4,978,879	8.96	446,077
Arkansas, Colorado, Wyoming	766,988	16.5	126,582	1,438,053	11.5	164,930
North Dakota	940	52.0	235	7,960	31.2	2,480
Missouri	108,090	15.7	17,010	152,280	14.8	22,592
Tennessee	2,000	15.0	300	2.200	15.9	350
South Dakota	37,500	52.0	19,500	36,400	67.0	24,400
Oregon	400	25.0	100	700	35.7	250
Iowa	Nil	....	....	186	50.0	93
Total	406,622,119	13.33	54,222,399	402,140,730	13.59	54,640,374

(*a*) Statistics of U. S. Geological Survey.

In 1908 prices to industrial consumers ranged from 4.4c. per M. cu.ft. in Oklahoma to 51c. in South Dakota. Average prices in other States were as follows: West Virginia, 5.2c.; Kansas, 5.3c.; Illinois, 6.4c.; Pennsylvania, 10c.; Ohio, 11.6c., and Indiana, 15.7c. The average price for the country was 8.2c. per M. cu.ft. The total consumption in manufacturing industries was 261,556,998 M. cu.ft. and for domestic purposes 140,583,732 M. cu.ft. The average price to domestic consumers was 23.6c. per M. cu.ft. The total number of producing wells on Jan. 1, 1909, was 21,375, of which 2148 were drilled in 1908.

California.—In 1909 the production of natural gas in California amounted to 1,147,502 M. cu.ft., valued at $616,447, as compared with 478,698 M. cu.ft. in 1908, valued at $307,652. A large part of this output was derived from the Santa Maria oil field, where the gas occurs in connection with the oil. There are no dry gas wells in this field, but the gas is separated from the oil in gas traps. The large increase in the output of the State was principally due to the unusual activity in the oilfields, and the increased use of the gas produced from the oil wells. There were 57 productive gas wells in the State on January 1, 1909. About 70 per cent. of the total production was used for industrial purposes.

Kansas and Oklahoma. (By Erasmus Haworth.)—No remarkable developments were made during 1909 either in the production of the gas wells or in the extending of gas pipe lines. The Kansas Natural Gas Company remained by far the largest producer and vender of gas for fuel. In the very heart of the gas territory a number of cities and towns which formerly had an independent supply of gas are now connected with the pipe lines of this company. The extension of pipe lines was confined entirely to connecting up more generally, with residences, business houses, small factories, etc., in territory already covered.

Much complaint was made during the early part of 1909, in Kansas City, St. Joseph and Topeka, particularly, and in some other towns to a lesser extent, because the gas supply was insufficient to meet the demands of consumption for domestic purposes. Governor Stubbs, of Kansas, it is reported, instructed the State's attorney general to look into the matter, and should he find sufficient legal encouragement, to enjoin the Kansas Natural Gas Company from piping gas out of Kansas until its Kansas consumers, with whom it has life contracts, are first served.

North Dakota.—During 1908 and 1909 discoveries of natural gas in Bottineau and eastern Ward counties caused considerable excitement. Four wells drilled about 9½ miles south of Westhope, near the point of original discovery, showed good flows, while three others drilled to the north toward Westhope were unsuccessful. The Great Northern Oil, Gas and Pipe Line Company is developing the field. The gas-bearing sand lies at depths ranging from 154 to 176 ft. and varies in thickness from 16 to 20 ft. A pressure exceeding 100 lb. per sq.in. and a flow of 2,000,000 cu.ft. per day is reported for each of the successful wells. An analysis of the gas shows hydrogen, 0.5 per cent; methane, 82.7; ethylene and other illuminants, 0.2; carbon monoxide, 1.2; oxygen, 3, and nitrogen 12.4. The gas has a calculated heating value of 886 b.t.u.

At Mohall there are two wells which yielded gas. They are about 7 miles west and north of the town and about 26 miles west of the wells at Westhope. Gas has also been reported as having been struck at a depth of 200 ft. at Maxbass, 16 miles southwest of Westhope; Lansford, 10 miles southeast of Mohall, and at the McCaslin farm, 14 miles southwest of Mohall. It is impossible at present to definitely outline the possibilities of the Bottineau gasfield. The gas is now being used locally in farm houses, and it is proposed to pipe it to Westhope and later to other surrounding towns.

In Lamoure county there were six producing wells in 1908, one of which supplied gas for power to an electric light plant in the town of Edgeley, the others being used for domestic purposes.

Ohio. (By J. A. Bownocker.)—The natural gas industry was very quiet during 1909. The one large field in central Ohio furnished the bulk of the output, the producing sand being the Clinton. The central Ohio field was discovered more than 20 years ago, and from time to time large additions have been made to it. With the extension of the known gas-bearing area, pipe lines have been laid to city after city, until an immense population has come to rely upon the gas for both domestic and industrial purposes. No additions were made to the field during 1909, and already the cry "insufficient gas" has been heard. About one-half the gas consumed in the State during the year was piped from West Virginia and Pennsylvania. Apparently the zenith of production has been passed, and the decline will be rapid. One company has connected an 18-in. line from West Virginia with its Ohio lines, and is prepared for the inevitable. Early in January, 1910, Columbus for the first time was using natural gas that was in part secured from West Virginia.

Texas and Louisiana.—During 1909 many gas wells of large capacity were drilled in the Caddo and Henrietta fields. Those in the latter district were utilized to supply gas to Henrietta, Petrolia, and Wichita Falls, and half of the 125-mile line to Dallas and Fort Worth was constructed. The Mississippi Valley Gas and Pipe Line Company obtained a franchise to supply New Orleans from the Caddo field and are actively developing wells of ample capacity in the Vivian pool. The proposed pipe line will be about 350 miles long and will cost $7,000,000, while the franchise stipulates that gas must be supplied within 30 months for 45c. per thousand feet up to a consumption of 60,000,000 ft., and over that amount for 40 cents.

West Virginia. (By I. C. White.)—In 1909 the production of natural gas in West Virginia increased greatly, and in spite of the enormous waste of the gas incident to the petroleum industry, the State is second only to Pennsylvania in the quantity and value of its output. The Calhoun, Roane and Lincoln county gas fields were greatly extended during 1909, the latter two being now the largest fields of the State. The limit of both these great pools remain as yet undefined, and search for their bounderies still proceeds. A small gas and oil pool in the Berea sand was opened on Falling Rock creek just south of Elk river in Kanawha county. Several large wells were developed in southern Wayne county, near Dunlow, and it looks as though the gas field of the southwestern portion of the State may extend into Logan, Mingo and Boon counties, and possibly into Wyoming, Raleigh and McDowell counties. Some fair gas wells were sunk near Frenchton, Upshur county, apparently in the same pool with the wells drilled several years ago, near Craddock.

A large portion of the gas produced in the State was piped to cities and towns in northern Ohio. On July 1, 1909, the pipe line supplying gas to the cities of Cincinnati, Ohio, and Covington, Ky., was completed and in operation. This line starts at Culloden, W. Va., with 33 miles of 18-in. pipe running to the Big Sandy river. From this point there are 126 miles of 20-in. pipe to Covington, Ky., where the line terminates in two 12-in. pipes which cross the suspension bridge into the city of Cincinnati. In addition to the main line there are over 25 miles of 8-in. and 12-in. lines running south from Culloden into the gas fields of Lincoln and Wayne counties, and at least 25 miles of smaller field lines connecting the various gas wells. This system can deliver 17,000,000 cu.ft. of gas per day. Gas from West Virginia is also piped into Maryland, where it supplies many of the cities and towns in Allegheny county.

Natural Gas in Foreign Countries.

Canada.—There was an increased production of natural gas in Canada in 1909. The consumption amounted to over 6,000,000 M. cu.ft. Receipts from gas sold in 1909 were $1,205,943, as compared with $1,012,660 in 1908. About 95 per cent. of the output was derived from Welland, Haldimand, Norfold, Kent, Essex and Bruce counties in Ontario. The balance of the production was supplied by wells at Medicine Hat and vicinity in Alberta.

Hungary.—The first important discovery of natural gas in Europe was reported in 1909 from Kis-Sarmas, in the district of Klausenburg, in Hungary. The presence of the gas first became known in 1907, when boys used to light the vapors rising from the marshes. Upon a geologist's report the ministry of finance directed borings to be made, when large quantities of gas were discovered at a depth of 60 ft. The borings were continued to a depth of 600 ft., when gas was found in such volume that big stones were thrown into the air by it. At the present time the gas is flowing out of a pipe with a noise that can be heard six miles away. The flow is estimated at 6,000,000 cu.ft. per 24 hours. Analysis shows that it is a particularly pure methane gas, containing scarcely $\frac{1}{2}$ per cent. of nitrogen. Upon the advice of experts the Hungarian ministry of finance has bought the gas rights for $21,000. It is proposed to utilize the supply in running a large central electrical plant to be built on the ground.

Russia.—At Surachany and Amiradschan in the Baku oilfield, natural gas has been used for a long time on a small scale as fuel for burning lime, and more recently on a larger scale in petroleum distilling plants. Such a large supply of gas was opened up in the Surachany plain in 1903, that it became possible to use it as fuel in the adjacent Balachany oilfield as well as in the district of its origin. The use of natural gas at Baku is of considerable importance, for 15 per cent. of the total production of crude oil in this oilfield is used in producing power; moreover the yield of crude oil is steadily falling and the price rising. The amounts of gas used as fuel in 1909 was 117,130,000 cu.m., and in 1908 (Jan. 1 to June 1), 27,920,000 cu.m. About 1037 cu.m. of the gas are equivalent in fuel value to 1 metric ton of crude oil.

NICKEL AND COBALT.

By Frederick W. Horton.

In 1909 the nickel and cobalt produced in the United States from domestic ores was, as in previous years, but a small fraction of the total output, which was derived almost entirely from ore and matte imported from Canada. The North American Lead Company, of Fredericktown, Mo., produced electrolytic nickel and cobalt oxide as by-products in treating lead ores from Madison county. The output of this company, which was probably not in excess of 500,000 lb. of nickel, was the only production on a commercial scale from domestic sources. In Jackson county, N. C., extensive developments were carried on by the Consolidated Nickel Company, which is preparing to work nickel ore deposits at Webster. A large experimental plant was erected for treating the ore by electric furnace methods and the results so far obtained are reported as satisfactory.

The ore at Webster consists of hydrated nickel magnesium silicates, chiefly garnierite and dunite, and contains an average of about 2 per cent. nickel. At present this low-grade ore is being smelted in an electric furnace in lump form with about 10 per cent. of crushed coke to produce a silicate of nickel and iron, which it is proposed to use directly in the manufacture of nickel-steel. Analyses of various silicides, which

UNITED STATES IMPORTS AND EXPORTS OF NICKEL AND COBALT.
(In pounds, and tons of 2240 lb.)

Year.	Imports.							Exports.	
	Nickel Ore and Matte.		Nickel Alloys. (a)		Nickel Mnfrs.	Cobalt Oxide.		Nickel. (b)	
	Long Tons.	Valuc.	Pounds.	Value.	Value.	Pounds.	Valuc.	Pounds.	Value.
1897..	12,420	$781,483	(c)	....	....	24,771	$34,773	4,255,558	$997,391
1898..	26,826	1,534,262	(c)	....	....	33,731	49,245	5,657,618	1,359,609
1899..	19,857	1,216,253	(c)	....	....	46,791	68,847	5,004,377	1,151,923
1900..	25,670	1,183,884	455,188	$139,786	....	54,073	88,651	5,869,906	1,382,727
1901..	52,111	1,637,166	635,697	209,956	$2,498	71,969	134,208	5,869,655	1,521,271
1902..	14,817	1,156,372	752,630	251,149	30,128	79,984	151,115	3,228,607	925,579
1903..	15,936	1,285,935	521,344	170,670	37,284	73,350	145,264	2,414,499	703,550
1904..	8,548	915,470	589,555	203,071	2,950	42,352	86,925	7,519,206	2,130,933
1905..	13,451	1,626,920	941,966	331,920	3,291	70,048	139,377	9,550,918	2,894,700
1906..	15,156	1,816,631	210,000	77,373	8,963	41,084	83,167	10,620,410	3,493,643
1907..	(d)16,888	2,153,873	180,025	80,994	9,159	42,794	73,028	8,772,578	2,845,663
1908..	(e)16,322	2,396,217	241,868	91,388	10,010	1,550	3,095	9,770,248	3,297,988
1909..	(f)18,578	2,927,975	277,911	104,019	4,279	9,818	11,065	12,048,737	4,101,976

(a) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars and sheets. (b) Comprises domestic nickel, nickel oxide and matte. (c) Not separately enumerated; included in "Nickel Ore and Matte." (d) Contained 18,418,305 lb nickel; not reported previous to 1907. (e) Contained 16,586,423 lb. nickel. (f) Contained 21,916,182 lb. nickel.

have been produced, show nickel, 10 to 30 per cent.; silica, 20 to 30; iron, 40 to 50; aluminum, 5 to 10; chromium, 3 to 5, and carbon, magnesium, sulphur and phosphorous, from 3 to 4 per cent. The experimental furnace used is of the ordinary arc type and is run with a normal current of 6800 amp. at 50 volts. The electricity is generated by four direct-current generators, driven by a 1000-h.p. Hamilton-Corliss engine. Electricity will ultimately be generated from water power, of which 8000 h.p. is available within a few miles of the mine. When operating on a commercial scale, the company contemplates not only the production of nickel silicide, but also of metallic nickel, ferro-nickel and chrome-nickel alloys.

Outside of the North American Lead Company, the Orford Copper Company and the Balbach Smelting and Refining Company are the only producers of metallic nickel in the United States. We are unable to report precise statistics of production, but, on the basis of importations of ore and matte, we estimate the output of the metal in this country at 20,-500,000 ℔. in 1909, against 14,000,000 ℔. in 1908.

Market and Prices.—The market for nickel was unchanged in 1909, the control of the industry being vested in the International Nickel Company, which, with the French company, Le Société le Nickel (the owner of principal mines in New Caledonia), and the Mond Nickel Company (the only other producer in Sudbury), fix the price of the metal in all markets. The schedule of prices to the retail trade in 1909 is given in the accompanying table:

PRICES OF NICKEL FOR RETAIL PURPOSES IN 1909.
(In cents per pound.)

Not less than	Shot.	Grain.	Electrolytic.
2000 ℔	50	52	55
1500 ℔	51	53	56
1000 ℔	52	54	57
500 ℔	55	57	60
100 ℔	60	62	65
50 ℔	65	67	70

Contract business in large lots with producers of nickel-steel was done at 40@45c. per ℔. and it is reported that the price of the metal to various concerns engaged in building warships for their respective Governments was as low as 26c. per ℔. As the cost of production from Sudbury ore does not exceed 15c. per ℔., these prices explain the report of the International Nickel Company for the year ended March 31, 1910, which showed a net profit of $2,067,528 after deducting operating expenses, $305,025 for depreciation of plants, $123,581 for exhaustion of minerals, and $184,000 for a sinking fund. The report states that the demand for the company's product was much larger than during the previous year, indicating a broadening of the normal market. Crude nickel oxide containing 77 per cent. nickel was quoted at 47c. per lb.; the mono-sulphate at 9@11c. and the double sulphate at 6½@8c. per pound.

A violent rate war between the two producers of cobalt oxide occurred in 1909. The price rose slightly at the beginning of the year and averaged about $2 per lb. throughout January and February. In March there was a sharp drop to $1.30 per lb., where the price remained until August, when the average quotation for the month was $1.40. In September the average price rose to $1.42½ per lb. and remained at this figure throughout October and November. A sharp decline on December 1 practically cut the price in two, the quotation dropping to 82½c. per lb., at which figure the market closed. The average price for 1909 was $1.42 per lb., as compared with $1.61 per lb. in 1908.

Nickel and Cobalt Mining in Foreign Countries.

Canada.—The Canadian nickel industry was particularly active in 1909, and the production was the largest on record. The Sudbury district continued to be the chief producer, although important quantities of nickel were derived from the cobalt-silver ores of the Cobalt district. Statistics of the industry for a period of years are given in the accompanying tables:

PRODUCTION, EXPORTS AND IMPORTS OF NICKEL IN CANADA. (*a*)

Year.	Production.		Exports.		Imports.
	Pounds. (*b*)	Value. (*c*)	Pounds. (*d*)	Value. (*e*)	
1900	7,080,227	$3,327,707	13,493,239	$1,040,498	$6,988
1901	9,189,047	4,594,523	9,537,558	958,365	12,029
1902	10,693,410	5,025,903	3,883,264	834,513	15,448
1903	12,505,510	5,002,204	9,032,554	878,159	26,177
1904	10,547,883	4,219,153	14,229,973	1,237,307	16,330
1905	18,876,315	7,550,526	11,970,557	1,185,056	19,076
1906	21,490,955	8,948,834	20,653,845	....	(*f*)15,808
1907	21,189,793	9,535,407	19,376,335	....	(*g*)
1908	19,143,111	8,231,538	19,419,893	....	(*g*)
1909	26.282.991	9,461,877	25,616,398	2,676,483	(*g*)

(*a*) Statistics for production and imports cover calendar years, and are taken from the Annual Reports of the Geological Survey of Canada. Figures for exports cover the fiscal years ending June 30, and are taken from the Statistical Year Book up to 1905 inclusive. Subsequent figures are for calendar years as reported by the Canadian Geological Survey. (*b*) Pounds metallic nickel contained in copper and nickel matte exported. (*c*) On the basis of refined nickel at New York, from the *Engineering and Mining Journal* average annual quotations. (*d*) Pounds of nickel contained in ore, matte or speiss. (*e*) Spot value, to the producer, of the exported material; the variety of stages at which the material is shipped, as well as the different periods of time covered, lead to the apparent discrepancy in value when it is known that practically the entire production is exported. (*f*) Anodes only. (*g*) Not reported.

NICKEL EXPORTS FROM CANADA.
(In Pounds)

	1906	1907	1908	1909
To Great Britain....	2,716,892	2,518,338	2,554,486	3,843,763
To United States...	17,936,953	16,857,997	16,865,407	21,772,635
Total............	20,653,845	19,376,335	19,419,893	25,616,398

The only companies which carried on active operations in the Sudbury district were the Mond Nickel Company at Victoria Mines and the Canadian Copper Company at Copper Cliff, the latter company being the local representative of the International Nickel Company. The nickel-copper ores of the district are first roasted and then smelted to a bessemer matte, containing from 77 to 82 per cent. of the combined metals, the matte being shipped to the United States and Great Britain for refining. The accompanying table shows the aggregate results for a period of years of operations on the Sudbury ores.

ONTARIO NICKEL STATISTICS.
(In tons of 2000 lb.)

Schedule.	1903	1904	1905	1906	1907	1908	1909
Ore raised..........	152,940	203,388	277,766	343,814	351,916	409,551	451,892
Ore smelted........	220,937	102,844	251,421	340,059	359,076	360,180	462,336
Per cent. nickel.....	3.16	4.58	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Per cent. copper...	1.81	2.41	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Ordinary matte.....	30,416	19,123	17,388	20,364	22,041	21,197	25,845
Bessemerized.......	14,419	6,926					
Nickel content......	6,998	4,743	9,438	10,745	10,602	9,572	13,141
Copper content......	4,005	2,163	4,386	5,265	7,003	7,503	7,853
Value of nickel (*a*)..	$2,499,068	$1.516,747	$4,019,814	$4,629,011	$3,291,355	$2,930,989	$3,913,012
Value of copper (*a*)..	$583,646	$297,126					
Wages paid.........	$746,147	$570,901	(*b*)	$1,117,420	$1,278,694	$1,286,265	$1,234.903
Men employed......	1,277	1,063	(*b*)	1,417	1,660	1,690	1,735

Note.—The quantity reported in 1903 under "bessemerized matte" includes both bessemerized matte and high-grade matte, the former being the product of the Mond Nickel Company's works and the latter of the Ontario Smelting Works, which re-treat the low-grade matte produced by the Canadian Copper Company. (*a*) Value based on nickel and copper in matte and not on refined metals. (*b*) Not available.

The production of cobalt-silver ores in the Cobalt district showed a considerable increase over the previous year, but not so large an advance as was made in 1908. According to returns received from 31 producing mines, there were shipped during 1909 about 28,042 tons of ore and 2967 tons of concentrates, a total of 31,009 tons. The silver content of the ore shiped was 22,581,788 oz., or an average of 805.3 oz. per ton, and of the concentrates, 3,639,475 oz., or an average of 1226.7 oz. per ton. Bullion shipped from the mines contained 143,440 fine ounces of silver, making the total silver content of ore, concentrates and bullion 26,364,703 oz. Payments for cobalt contents were reported as $90,750.

The accompanying table shows the quantity and value of the silver produced in the district beginning with 1904, when the first commercial shipments were made:

PRODUCTION OF SILVER IN THE COBALT DISTRICT.

Year.	Production, Oz.	Value.
1904	206,875	111,887
1905	2,451,356	1,360,503
1906	5,401,766	3,667,551
1907	10,023,311	6,155,391
1908	19,400,640	9,115,818
1909	25,128,590	12,941,978
Total	62,612,538	33,353,128

The mine owners received no payment for the nickel content of these silver-cobalt ores and complete statistics are not available as to the total quantity of nickel produced from them. Of the total shipment, 8384 tons were treated in Canadian metallurgical works at Copper Cliff, Del Oro and Thorold, producing silver bullion and white arsenic. The speiss, or residues from these operations amounted to 2660 tons and contained silver, cobalt, nickel and arsenic, the nickel content being 758,966 lb. and the cobalt content 1,721,083 pounds.

(By Thomas W. Gibson.)—The nickel mines of the Sudbury district were vigorously worked in 1909, the output of nickel ore amounting to 451,892 tons, a considerable advance over the production of any previous year. The value of the nickel in the matte was placed by the producers at $2,790,798, The production was wholly from the Canadian Copper Company, at Copper Cliff, and the Mond Nickel Company, at Victoria Mines. The former company confined its operations largely to the Creighton and Crean Hill mines, both carrying nickel and copper. In the Creighton mine the nickel predominates, and at the Crean Hill property the copper. The Canadian Copper Company exported its bessemer matte to the United States for further treatment, and the Mond company sent its bessemer product to Wales. The Dominion Nickel-Copper Company is building a railroad from the Canadian Northern to the Whistle mine.

During 1909 a new nickel area was exploited in the township of Dundonald, a short distance west of the Temiskaming & Northern Ontario railway, near Frederick House lake. A body of pyrrhotite, very like that of the Sudbury mines, was located by a prospector named Kelso. The nickel contents of the ore vary somewhat, but are well within the workable limit. An option was taken on the property by the Canadian Copper Company, but after exploitation by the diamond drill it was abandoned, owing, it is said, to the limited size of the orebody.

In the Cobalt district the mines are worked primarily for silver, although the ore contains other elements of value, namely, cobalt, nickel and arsenic, but the latter two bring no returns to the mine owner, and the enforced production of cobalt ore is far in excess of the world's consumption. The chief producers during the year were Nipissing, Crown Reserve, O'Brien, La Rose, Kerr Lake, Coniagas, Trethewey, Buffalo, Temiskaming & Hudson Bay, clustering around Cobalt station on the Temiskaming & Northern Ontario railway. In southeastern Coleman, the Temiskaming worked rich, but somewhat irregular, deposits in the Keewatin, and ore was also found on the adjoining property, the Beaver. In the neighboring camp of South Lorrain, to the east, several mines are likely to become of importance, among them the Wetlaufer, Keeley and the mine of the Haileybury Silver Mining Company. Anvil Lake, Elk Lake and Gowganda are still under development, and some properties will make shipments of ore during the present winter. None of these camps, however, have so far proved equal to Cobalt.

Concentration plants for low-grade ore are becoming numerous in the Cobalt camp, and most of the high-grade ore is treated in Ontario. There are reduction works at Copper Cliff, Deloro and Thorold. Part of the high-grade ore and most of the low-grade goes to smelteries in the United States.

Mexico. (By Kirby Thomas.)—A nickel-cobalt deposit was discovered in western Chihuahua in 1906, but no exploitation has been undertaken. Nickel as an oxide or arsenide is reported in the Toliman district, Queratero. Small shipments of an ore running 30 per cent. cobalt and 7.40 per cent. nickel were made several years ago from the Esmeralda and Pihuano mines in Jalisco. The deposits are reported as occuring in small lenses in an iron formation. Several tons of nickel-cobalt ore have been shipped from Tepic, but the deposits have not been found extensive enough to warrant development.

New Caledonia.—Exports of nickel and cobalt ore from New Caledonia in 1909 fell off to a large extent. Only 82,937 metric tons of nickel ore, valued at £100,283, were shipped during the year. Of this amount approximately 35,000 tons went to England, 25,000 tons to France, and the remainder to Belgium, Holland and Germany. The Société le Nickel and the Ballande company were the only exporters. The production of nickel ore during the year may be estimated at 120,000 tons, and the stock on hand in the colony, on Dec. 31, 1909, at not less than 122,000 tons. The great decrease in the amount exported is explained by the fact that a number of contracts were made during the year for forward delivery, and all stocks of ore in the colony became the property of the smelters. Several large contractors were not inclined to make agreements covering too long a period, feeling confident that better prices would prevail in the near future. The necessity of smelting the nickel ores on the island has been realized, and three nickel reduction works are now in course of construction. One of these at Tau is to use an electric furnace process by which it is claimed that nickel can be produced at a cost which will enable the selling price to be reduced from £190@200 to £100 per ton.

Shipments of cobalt ore in 1909 amounted to only 979 metric tons, valued at £2885. This material can no longer successfully compete with Canadian cobalt ore, and due to the high export tax, coupled with lack of demand and the extremely low price of cobalt, the New Caledonian producers have closed down their mines. The stocks in the colony are probably 400 to 500 tons.

During 1909 the freight rate from Noumea to European ports was £1 3s. 6d., on both cobalt and nickel ores. The accompanying table gives the exports of nickel and cobalt ore from the colony for a period of years:

SHIPMENTS OF NICKEL AND COBALT ORES FROM NEW CALEDONIA. (a)
(In metric tons.)

	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909
Nickel ore	100,319	133,676	129,653	77,360	98,655	125,289	130,688	101,708	120,028	82,937
Cobalt ore	2,400	3,110	7,512	8,292	8,961	7,919	2,487	3,943	3,405	979

(a) Reported by *Le Bulletin du Commerce*, Noumea.

Norway.—The nickel mines at Evje, in Saeterstal, in 1909 produced 6600 metric tons of nickel ore. The smelting of this yielded 168 metric tons of copper-nickel matte, which contained 70 metric tons of nickel. The matte was exported. Recently it has been decided to erect an electric plant for the production of nickel from this product.

USES.

Probably two-thirds of the world's total production of nickel is used in the manufacture of nickel-steel, and one-third in the production of white metal, Monel metal and similar alloys, nickel coinage, electroplating, etc. Nickel-steel is used for propeller shafts, crank-pins, ship plates, rifle barrels, automobile frames, etc., but the one large use which consumes the bulk of the output is the manufacture of armor plate, turrets and big guns. Steel used for the latter purposes usually contains 3½ per cent. nickel. The properties and uses of Monel metal were thoroughly described in Vol. XVII of The Mineral Industry. It may be of interest to add that during 1909 the United States battleships "Florida" and "North Dakota," as well as several other government vessels, were equipped with propellers of Monel metal and the two Argentine Republic battleships now being constructed are to be similarly equipped.

The principal use of cobalt is in the manufacture of the so-called cobalt-blue pigments and as a coloring matter in the glass and enamelware industries.

Bibliography of Nickel and Cobalt in 1909.

Browne, D. H. "Monel Metal." (*Electrochem. and Met. Ind.*, Mar., 1909; 1 p.)

Gray, A. "The Nickel Trust." (*Min. Journ.*, Jan. 16, 1909; 2 pp.)

Parry, L. "The Assay of Zinc and Nickel." (*Min. Journ.*, June 12 and 26, 1909; ½ p.)

Pitaval, R. "L'Electrométallurgie du nickel." (*Journ. Four Elect.*, July 15, 1909; 1 p.)

Schmidt, C. and Verloop, J. H. "Notiz Uber Lagerstätte von Kobalt und Nickelerzen bei Schladming in Steiermark." (*Zeit f. prakt. Geol.*, June, 1909; 5½ pp.)

PETROLEUM.

By Frederick W. Horton.

The condition of the petroleum industry in the United States in 1909 on the whole was decidedly unsatisfactory. Although the production was the largest in the history of the industry, amounting to 180,908,696 bbl., it exceeded the output in 1908 by only 235,455 bbl. Even this slight increase was unexpected in view of the great accumulation of stocks during 1908, which was chiefly the result of the exceptionally prolific yield in the mid-continental and Illinois fields. These stocks were more than the market could absorb, and their existence was directly responsible for a decline in the price of crude oil in the eastern and mid-continental fields in 1909.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES
(In barrels of 42 gal.)

Field.	1903	1904	1905	1906	1907	1908	1909
California (*a*)	24,337,828	28,476,025	35,671,000	30,538,000	40,085,000	45,000,000	58,250,300
Colorado	483,925	(*b*) 501,763	(*e*) 550,000	600,000	400,000	411,836	(*e*)500 000
Gulf: Texas	17,955,572	21,672,111	30,354,263	12,666,000	12,350,000	11,206,464	9,256,000
Gulf: Louisiana	917,771	6,611,419	9,672,015	7,100,000	4,620,000	6,835,130	3,220,000
Illinois	....	....	....	4,900,000	24,540,024	33,685,106	30,000,000
Lima: Indiana	9,177,122	10,744,849	22,102,108	25,680,000	8,030,000	7,287,000	6,192,000
Lima: Ohio	14,893,853	13,350,060					
Mid-Continental (*c*)	1,157,110	5,617,527	12,000,000	21,929,905	47,556,906	50,741,678	46,826,196
Ky.-Tennessee	(*f*)	998,284	(*e*) 1,200,000	1,000,000	1,250,000	1,250,000	(*e*)1,250,000
Pennsylvania (*d*)	29,897,815	(*b*)30,410,183	28,324,324	27,345,600	25,500,000	24 240,000	25,394,200
Wyoming	8,960	11,542	(*e*) 12,500	13,000	13,000	(*e*)13,000	(*e*)15,000
Others	3,000	2,572	(*e*) 3,000	4,000	3,000	(*e*)3.000	(*e*)5,000
Total	98,832,956	118,396,335	139,889,210	131,771,505	164,347,930	180,673,241	180,908,696

(*a*) Reported by the California Producers' Association, except the statistics for 1907, 1908 and 1909, which are of our own collection. (*b*) Statistics of the U. S. Geological Survey. (*c*) Kansas and Oklahoma. (*d*) Pennsylvania, New York, West Virginia, Eastern Ohio, and, until 1904, Kentucky and Tennessee. (*e*) Estimated. (*f*) Included in Pennsylvania.

At the beginning of the year Pennsylvania crude sold for $1.78 per bbl. A break in prices came in April, and finally in November sales were made at $1.43 per bbl. The average price during the year was $1.62 per bbl., as compared with $1.78 in 1908 and $1.74 in 1907. In the Lima field the price dropped from $1.04 per bbl. to 84c., and in Illinois from 68c. per bbl. to 60c. The price of Oklahoma light oil declined from 41c. per bbl. to 35c. In Kentucky, the decline was 28c. on high-grade oil and 15c. on low-grade. The break in the price of Pennsylvania crude was also influenced by the decrease in the export movement of illuminating oils brought about by the intensified competition of the product of other countries in the foreign market. Another theory advanced for the marked decline of Pennsylvania crude oil was that former prices were out of proportion in their relation to those of the products of other fields, and it is significant that the depreciation in Pennsylvania grades (35c.) was more than that for the oil of any other field.

The quantity of crude, lubricating and paraffin oils, naphthas and residuum exported from the United States in 1909 exceeded that in 1908. The only decrease in volume of exports was in illuminating oil, which fell off 82,603,811 gal. The total value of the exports of crude oil and its products in 1909 was $103,838,590, or $4,976,865 less than in 1909.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (In gallons.)
(1=1000 in quantities and values.) (a)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffin.		Residuum.		Totals	
1897	121,864	$5,044	13,704	$1,020	804,446	$46,876	52,659	$6,732	(b)12,247	$ 335	1,004,920	$60,007
1898	120,436	5,016	17,258	1,071	764,823	38,895	65,526	7,626	(b)30,436	815	998,479	53,423
1899	117,690	5,958	18,210	1,597	733,382	49,172	71,116	8,658	(b)21,609	658	962,007	66,043
1900	133,161	7,341	18,570	1,681	739,163	54,693	71,211	9,933	(b)19,750	845	986,855	74,493
1901	127,008	6,038	21,685	1,742	827,479	53,491	75,306	10,260	(b)27,596	1,255	1,079,059	72,786
1902	145,234	6,331	19,683	1,393	778,801	49,079	82,200	10,872	(b)38,316	922	1,064,234	68,597
1903	126,512	6,782	12,973	1,519	691,837	51 356	95,622	12,690	(b) 9,753	282	936,697	72,629
1904	111,176	6,351	24,989	2,322	761,358	58,384	89,738	12,389	34 904	1,174	1,022,165	80,620
1905	126,185	6,086	28,429	2,215	881,450	54,901	113,730	14,312	70,728	2,128	1,220,513	79,641
1906	148,045	7,731	27,545	2,488	878,274	54,858	151,269	18,690	64.645	1,971	1,269,788	85.738
1907	126,306	6,334	34,625	3,676	905,924	59,635	152,029	19,210	75,775	2,528	1,294,660	91,383
1908	149.190	6.520	43.890	4,542	1,129.005	75.988	147.769	18,971	77,552	2,793	1,547.405	108.815
1909	186,305	6,568	68,759	5.800	1,046,401	67,814	161,640	20,016	107,999	3.640	1,571,103	103,839

(a) In addition to the above, the following quantities of paraffin and paraffin wax were exported (1=1000): 1897, 136,069 lb. ($5,284); 1898, 166,317 lb. ($6,363); 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,268 lb. ($8,398); 1903, 204,120 lb. ($9.596); 1904, 174,582 lb.($8.273), 1905, 160,836 lb. ($7,873); 1906, 173,504 lb. ($8,463); 1907, 207,504 lb. ($10,209); 1908, 141,667 lb. ($6,923); 1909 181,328 lb. ($7,609). (b) Reported in barrels of 42 gallons.

California was pre-eminently the largest producer in 1909 and showed a very satisfactory increase in output, the total being nearly 30 per cent. larger than in 1908. The values realized by the producers were also large, as the steadily increasing market readily absorbed all holdings. As the product of the State exceeds that of all other fields in its yield of fuel oil, amounting to 72 per cent. of the total output, the enormous gain in the consumption of liquid fuel on the Western coast, as well as in the foreign markets most accessible to Californian shipments, may be regarded as the occasion for the unusually favorable showing of the State in 1909.

The mid-continental field took second place in 1909, its output being 7 per cent. less than in 1908, when it led the producing districts of the country. The maintenance of production was in the face of rather adverse conditions, and the congestion of stock in this field was regarded as one of the leading factors in the weakening of the crude oil situation.

Two declines of three cents each in the price of light oils took place during 1909, but the price of fuel oil remained unchanged. Late in the year conditions were more favorable, with runs and deliveries showing a more harmonious relationship, and at the close of 1909 the situation was more encouraging than it had been for several years past.

In the Illinois field, which ranked third in the list of producers, there was a considerable decline in output. This was but a natural result of the unusually heavy drain upon the resources of the State, which has been made during recent years. Considerable prospecting was carried on in 1909, but no new fields of consequence were discovered. In the districts which are the mainstay of Illinois production, some extensions of the producing area were made, but the most important development was the discovery of deeper oil sands which contributed large yields.

The Appalachian field made a slightly increased output in 1909, the more favorable showing being due to developments in West Virginia and southeastern Ohio. In Pennsylvania and New York the steady drain upon the resources of the fields resulted in a further decline in production, and wells drilled during the year were generally of small capacity. In West Virginia several new pools of consequence were exploited. The most important of these were the Shinnston development of Harrison county, which furnished some record producers. Active operations in Roane, Ritchie and Lincoln counties also tended to increase the production. In southeastern Ohio the most active developments of the year were carried on in the deep sands of the Clinton lime formation in Perry and Fairfax counties, but it is doubtful if returns justified the operations. The strike of a 500-bbl. well in the Steubenville pool in Jefferson county lent impetus to development work in that section.

The oilfields of Texas and Louisiana showed a greatly decreased production in 1909, every large pool except Caddo recording a smaller output than that in 1908. The decline was most marked in the Jennings field. Operations in the Caddo field were stimulated by the extension of shipping facilities to tidewater, and more active drilling resulted in the discovery of lower oil sands. The dissolution of the Waters-Pierce Company by the Federal Government was an important happening. On account of the decreased yield in this section prices were somewhat better.

The output of the Lima field of northwestern Ohio and Indiana continued to decrease. The most interesting features in this section in 1909 were the development of the Oakland City field in southwestern Indiana, where a number of wells of exceptional capacity were drilled, and the bringing in of some prolific wells in Randolph county, 20 miles distant from operations in the older field.

In Kentucky, Wayne county was the only district which maintained anything like its former production. The decrease in the output was attributed to the natural decline in the resources of the old shallow pools, and the lack of incentive to further development by reason of the poor market. Prospecting was carried on in all of the Western States, and was particularly active in Wyoming, Utah and New Mexico. The industry in the different producing fields is reviewed in detail in the following pages:

PETROLEUM OUTPUT OF THE WORLD. (a)
(In metric tons.)

	1903	1904	1905	1906	1907	1908	1909
United States	13.402,000	16.055,000	18,969,000	17,862,000	22,287,985	24,401,728	24,433,528
Russia	9,759,214	10,058,968	7,505,637	8,167,934	8,435,708	7,654,600	8,037,300
Dutch East Indies	662,767	955,957	1,062,224	1 186,907	2,200,000	2,348,000	(e)2,500,000
Galicia	675,518	826,077	794,862	739,885	1,176,000	1,754,002	2,150 000
Rumania	384,303	497,000	614,870	887,000	1,129,097	1,147,727	1,296,403
India	352,848	475,869	581,519	564.470	587,000	568,000	643,000
Other countries	250,000	250,000	350,000	367,000	(b) 590,000	(c) 880,000	(d) 910,000
Total	25.486,650	29,118,871	29,878,112	29,775,196	36,405,790	38,754,057	39,970.231

(a) In the above table the statistics for the United States are computed from the production reported in barrels as given in the first table of this article. As a gallon of the crude petroleum found in the United States varies in weight from 6.41 to 7.83 lb., the oil in a barrel varies from 269.22 to 328.86 lb. The arithmetical mean of these figures is 299.04 lb., which figure has been used as a factor in converting the output stated in barrels into metric tons. This is not strictly correct, because in the period from 1900 to 1909 the proportion of petroleum production of various gravities has altered materially, especially because of the largely increased production in California, Texas and Louisiana. However, the method adopted is as near an approximation as can be made at this time. (b) Includes 294.000 tons from Mexico (c) Includes 587,000 tons from Mexico. (d) Includes 405,000 tons from Mexico. (e) Estimated.

Review of the Oilfields of the United States.

Appalachian. (By Harold C. George.)—The Appalachian oilfield, for a number of years, has shown a steady decrease in production, but owing to the discovery of some large wells in West Virginia during 1909, a slight increase was recorded. The total production of the Appalachian field in 1909 was 25,394,200 bbl., as compared with 24,240,000 bbl. in 1908, 25,500,000 bbl. in 1907, and 27,345,000 bbl. in 1906. The development of the petroleum industry in Pennsylvania and New York during 1909 was a repetition of the history of these fields during the previous five years. The production was maintained only by drilling about 4000 wells with a daily average production per well of about 2½ bbl. Most of the oil territory in these two States is of the long-lived kind, owing mainly to the density of the sand rock containing the oil. In the Alleghany county field in New York, more than half of the producing wells, which number about 6000, were drilled 25 years ago. Hundreds of others equally as good were "pulled out" at the time of the big excitements in other fields, between the years 1882 and 1892, for the purpose of securing the "junk" for use elsewhere. During the last five years many of these abandoned wells have been redrilled and placed on a paying basis.

Drilling operations in Pennsylvania are naturally limited by the scarcity of available territory and the small wells secured. But territory which would have been considered of no value a few years ago is now secured and thoroughly drilled. The decrease in the market price of petroleum during 1909 had a tendency to limit operations and developments in Pennsylvania and other fields, where only small wells could be hoped for; not so much on account of the decrease itself, but more on account of the feeling of uncertainty that it created. Nearly all of the wells drilled in Pennsylvania during the year were small. A good well was struck in April in the Bradford sand at Smithport, McKean county. Probably the best well drilled in the State during the year was the one completed in October near Bakerstown, Allegheny county. The production during the first 24 hours was 350 barrels.

The Steubenville pool in Jefferson county has been furnishing the largest producers in Ohio. But the limited area of this field will not justify hopes of any great increase in production. Operations were active during 1909 in Fairfield and Perry counties. The wells drilled are not large, but they indicate the existence of considerable undeveloped oil territory. In the earlier part of the year one of the best wells credited to the eastern fields was drilled in Ludlow township, Washington county. It produced in the first 48 hours about 2500 bbl. In the Woodsfield district, Monroe county, some good producers were found as a result of extended field activity. Neither Jefferson nor Columbian county was very successful in field operations or new production.

West Virginia, during the last few years, has been the leading producer in the Appalachian field. Lincoln county led in active work and increased production during the earlier part of 1909. This was chiefly due to a number of fair producers in the Berea grit formation. Much exploration work was done in Putnam, Kanawha, Boone, Logan and Mingo counties, but with indifferent success. In August the best well drilled in the Appalachian field was found in the Shinnston pool in Harrison county. At its best it produced about 80 bbl. per hour, and it averaged about 1700 bbl. per day at the end of a week. This well furnished about half of the new production credited to West Virginia during the month.

Previous to August in 1909, southeast Ohio stood first in new production in the Appalachian field for the year, but at that time West Virginia resumed first place. In October a well was drilled in the Mannington district in Marion county, West Virginia. It produced 500 bbl. during the first 12 hours. Later it was shot and the production increased to 100 bbl. per hour.

In November the production of the Shinnston pool in Harrison county had reached 7000 bbl. per day by the drilling of a few very large wells. Early in December this pool furnished the largest gusher with one exception since the days of the big wells of the McDonald field. No accurate gage could be taken of the production at first, but it was variously estimated from 300 to 500 bbl. per hour. When finally controlled, the production reached 4000 bbl. during the first 24 hours. The production of the Shinnston pool in December averaged about 10,000 bbl. per day.

During the latter part of 1909 the Big Injun district in Roane county was most active in development work. This county has more wells drilled and started than any other in the southwest part of the Appalachian field. About the time that operations became more active in Roane county there was a marked decline in Lincoln county. There was considerable development work in Ritchie, Pleasant and Wirt counties during the year. In the "shallow sand" territory in Ritchie county the Grant and Murphy districts produced some good wells. The new wells in Wirt and Pleasant counties were mostly small producers. Developments in Kentucky were not especially promising. Nearly half of the wells drilled during 1909 were dry holes. The accompanying table shows a complete record of the new production in the Appalachian oilfield:

PRODUCTION OF WELLS DRILLED IN THE APPALACHIAN OILFIELD IN 1907, 1908 AND 1909.

Field.	Number of Wells Drilled.			Daily Production in Barrels.			Daily Production in Barrels per Well Drilled.			Per Cent. of Dry Holes.		
	1907	1908	1909	1907	1908	1909	1907	1908	1909	1907	1908	1909
Alleghany Co., N. Y.	575	493	468	1,114	880	838	1.9	1.8	1.8	16.0	13.4	7.5
Pennsylvania	3,611	3,748	3,958	12,176	9.532	10,361	3.3	2.5	2.6	21.0	19.0	15.6
West Virginia	1,320	1,329	1,810	21,300	27,304	35,872	16.1	20.6	19.1	38.0	32.5	36.9
Southeast Ohio	1,335	1,344	2,285	6,793	13,798	25,239	5.9	10.3	11.0	39.5	39.3	36.2
Kentucky	212	205	179	2,006	2,519	2,108	9.4	12.3	11.7	32.0	33.6	44.7
Total	7,053	7,119	8,700	43,389	54,033	81,918	6.1	7.6	9.4	27.0	25.0	25.6

West Virginia. (By C. White.)—Aside from some extensions of old developments in Ritchie, Pleasants, Marion, Monongalia, Tyler and Wetzel counties, the principal new fields of 1909 were those opened in the region of Shinnston, Harrison county; Walton, Roane county; and Griffithsville, Lincoln county. The sensation of the year was the finding of a gusher in the Shinnston field, which for a few hours flowed at the rate of 500 or more barrels per hour, and which was easily the greatest producer ever drilled in the State, its greatest day's output, much of which was lost through inadequate storage and pipe-line facilities, having been estimated at between 7000 and 8000 bbl. The oil is found in a very thick sand which appears to represent the Gantz and "Fifty-foot" combined, and some think the underlying "Thirty-foot" may also be included in the 120 to 130 ft. of sand, the thickness often reported. The oil occurs on a terrace-like shelf in the steep western slope of the strata descending from the Chestnut Ridge anticline, and 4 to 5 miles westward from its crest. This is the most northerly field in West Virginia to be found so close to the Chestnut Ridge axis, and many people think that perhaps other pools of either gas or oil, or both, may be found further to the northeast at the foot of the Chestnut Ridge slope through Marion and Monongalia counties, and especially after the Indiana anticline begins to affect the geologic structure.

The Calhoun, Roane and Lincoln county oilfields were greatly extended in 1909, the latter two now being the largest fields of the State. The limits of both these great pools remain as yet undefined, and search for their boundaries still proceeds.

A small "Big Injun" oil pool was developed on Four Mile creek, about 4 miles southwest from Sheridan in Lincoln county and west from the Guyandot river, but it is almost surrounded by gas wells and dry holes, so that it cannot be large. A small oil and gas pool was also opened in the Berea sand on Falling Rock creek south of Elk river in Kanawha county. The production of the State in 1909 probably exceeded 13,000,000 bbl., a considerable increase over the production for 1908, which amounted to 9,523,176 barrels.

California.—The production of petroleum in California in 1909 was the greatest in the history of the State, amounting to 58,250,300 bbl. This represents an increased output of 13,250,300 bbl. and beats the record of any field in the United States, and probably of any in the world. The value of the oil to the producer, on the basis of 56c. per bbl., which was the average price for all fields in the State, was $32,620,168, which exceeds the value of the gold output by several million dollars. The producing fields, in order of their importance, were Coalinga, Kern river, Santa Maria, McKittrick, Fullerton-Puente, Los Angeles, Sunset-Midway, Whittier-Coyote, Newhall-Venture, Watsonville, Tiber Pool and Summerland. The most notable increase in production was in the Coalinga field, where the output amounted to over 15,500,000 bbl., which is over a million barrels in excess of the production of the great Kern river field, although that field also increased its output. The Coalinga field gained 9500 bbl. daily over its production in 1908, and the Kern river field 7500 bbl. per day. The latter field has probably attained the zenith of its production, but an output of 50,000 bbl. per day is predicted for the Coalinga field in 1910. Every important field in the State, with the exception of the Santa Maria and Los Angeles. increased its output in 1909. The production of these fields decreased 5500 bbl. and 4300 bbl. per day respectively, and they will probably never exceed their present output. The following table gives statistics of well-drilling operations in the State in 1909:

WELL RECORD OF THE CALIFORNIAN FIELDS IN 1909. (a)

Field.	Wells Completed.	Wells Producing Dec. 31.	Drilling Jan. 1.	Drilling Dec. 1.
Coalinga	141	597	128	170
Kern River	87	1,370	75	45
Santa Maria	24	205	54	75
McKittrick	20	128	68	48
Fullerton-Puenti	28	284	34	39
Los Angeles-Salt Lake	67	652	48	32
Sunset-Midway	109	344	48	115
Whittier	8	148	8	12
Newhall-Ventura	23	335	6	23
Watsonville	1	5	....	1
Tiber Pool	2	8	1	3
Summerland	....	250	....	....
Other Districts	....	....	10	28
Totals	510	4,380	480	591

(a) From *Oil, Paint and Drug Reporter.*

In Ventura county a large number of old wells were cleaned out and operated in 1909, while in the Los Angeles field a number of wells were pulled and abandoned. The average daily output of wells for the entire State was approximately 40 bbl. The largest average was 112 bbl. per day in the Santa Maria field, and the smallest less than 1 bbl. per day at Summerland. A record production amounting to 5,236,372 bbl. was made during December.

The market for California oil in 1909 was the best in the history of the State. The demand is constantly increasing, and it is anticipated that 65,000,000 bbl. will be required to supply the market in 1910. The big increase in consumption during the year was entirely in the domestic market, and was due partly to finding new local markets and partly to expansion of the established markets brought about by the general improvement in business conditions. Out of the total production only 1,031,365 bbl. were exported, either as fuel oil or refined products, and although Japan would take large quantities of crude oil, little effort has been made to secure this market on account of the uncertainty of being able to meet the demand. In the domestic markets, the railroads, which are by far the largest consumers of fuel oil, greatly increased their demand. The Southern Pacific adopted oil in place of coal on its Nevada and Utah lines and the Santa Fé on its lines east of Winslow, Ariz., and the new Trans-Continental line. The Western Pacific placed a contract for nearly 5000 bbl. per day.

It is but a few years since fuel oil was selling for 15c. per bbl., but the price has gradually increased until at the beginning of 1909 the Standard Oil Company, in view of what then seemed an over-production, offered 40c. per bbl. for daily runs, but secured very little oil at this figure. It then advanced the price to 50c., and at the close of the year paid 65c. The indications are that lower prices will never again obtain but that production will be restricted by agreement when necessary. In the demand for by-products, the consumption of gasoline and distillates used in automobile and irrigation plants increased enormously, and the demand for asphalt was accelerated by the closing of the Trinidad plant of the Barber Asphalt Company.

During 1909 each of the three large competing companies, the Standard, Union and Associated, constructed 8-in. trunk pipe lines, connecting the fields in the San Joaquin valley with tidewater. The line of the Standard Oil Company starts in the Coalinga field and runs to Point Richmond, on San Francisco Bay. The Union's new line connects Coalinga, Kern river and all the valley fields with tidewater at Port Harford, in San Luis Obispo county, and the line of the Associated Oil Company connects Coalinga with Porta Costa, on San Francisco Bay. The last company also started construction on a pipe line from Coalinga to McKittrick, which will join the Coalinga-Porta Costa line. The completion of these new lines will give Coalinga a pipe-line capacity of 90,000 bbl. a day. The shipping facilities in all fields are now ample, and there is no danger of congestion in any field, even if the 1910 production should amount to 65,000,000 barrels.

Total stocks on hand in the California fields on Dec. 31, 1909, were estimated at 18,006,300 bbl., of which 15,531,300 bbl. were at Kern river, where the Standard Oil Company has tanks and reservoirs with a capacity of almost 12,000,000 bbl. The Associated has about 2,500,000 bbl. storage capacity, and the Union and individual companies probably have 5,000,000 bbl. more. The independent producers stored a portion of their oil in 1909, and have about 2,000,000 bbl. ready to ship as soon as the Independent pipe line is in operation. Very little of the stored oil represents an over-supply, except possibly that at Kern river.

Illinois. (By Raymond S. Blatchley.)—The production of oil in Illinois in 1909 fell below that of 1908, thus checking the phenomenal growth of the three preceding years. The production was a little more than 30,000,000 bbl. as against 33,685,106 bbl. in 1908. The pipe-line runs of the Ohio Oil Company for various months are given in the accompanying table. The miscellaneous receipts include tank-car shipments for the Indiana Refining Company, the Sun Oil Company, the Cornplanter Oil Company and the pipe-line runs of the Tidewater Company. The latter company was installed in the field during the earlier part of the spring.

RECEIPTS OF THE OHIO OIL COMPANY IN 1908 AND 1909.

Month.	1908. Bbl.	1909. Bbl.
January	3,595,787.28	2,494,492
February	2,701,071.37	2,358,198
March	2,783,874.58	2,568,393
April	3,529,127.04	2,388,309
May	4,100,079.34	2,536,413
June	3,913,527.73	2,365,956
July	2,871,073.65	2,413.218
August	3,750,872.41	2,411,483
September	3,299,991.51	2,203,705
October	2,978,379.99	2,228,269
November	2 674,738.20	2,149 372
December	2,725,178.15	2 130,737
Total	37,923,701.25	28,248,545

The general production for the first six months of 1909 held up to the average of 1908, but with the coming of summer the decline was marked. The cause for the check lies in the fact that the market was overstocked through continued drilling. This was somewhat further augmented by a drop in the price of oil. Early in the summer the price fell from 68c. per bbl. for oil above 30 deg. B. and 60c. per bbl. below 30 deg. B., to 65 and 57c. respectively. Later it declined to 62 and 54c., and finally in October to 60 and 52c., which were the prevailing prices for the two grades at the close of the year. The productive capacity of the field is far in excess of shipping facilities. Thus, on Dec. 31, the stock of the Ohio Oil Company amounted to 28,671,543 bbl.

The major development of the year took place in Lawrence county where the deep sands of the Chester formation immediately below the coal measures were sought for, these being more prolific than the upper sands. There are six productive sands ranging from 800 to 2000 ft. in depth that are attracting attention in this territory. A new pay sand was developed along the southwestern edge of the field in section 30 of Bridgeport township, where oil was found at a depth of 1975 ft. The initial and present daily yield of the well is 50 bbl. During December two new pools were located. The more important was discovered by the bringing in of a 100 bbl. well on the J. Stansfield farm, section 1, Lawrence township. The second pool was found in section 32 of Lukin township and adjoins the main field on the western side. These deep sands have not been tapped to the full extent because of an inactive market and increased expense from cavy conditions in the lower formations.

In Clark, Coles, Edgar and Cumberland counties there was a decrease in the number of drilling operations and in production. The shallow sands of these counties have gradually been drained until now the original wells are almost inactive. The production of Crawford county was sustained by the discovery of new marginal territory at Oblong, New Hebron and Flat Rock.

On Jan. 1, 1910, it was estimated that 16,497 wells had been drilled. Of these 2379 were dry holes. A record of drilling operations by months—taken from the *Oil City Derrick*—is given herewith; also the drilling record by counties in the eastern Illinois fields.

WELLS DRILLED IN ILLINOIS DURING 1909.

Month.	Average Initial Production, bbl.	Wells Completed.	New Production, bbl.	Dry Holes.
January	$29\frac{3}{8}$	213	5,060	41
February	$26\frac{1}{3}$	224	4,833	47
March	$29\frac{1}{3}$	216	5,018	45
April	$23\frac{1}{4}$	263	5,237	38
May	$27\frac{7}{8}$	321	7,681	45
June	$31\frac{1}{3}$	342	9,050	53
July	$33\frac{1}{5}$	346	9,820	50
August	$35\frac{1}{5}$	303	8,661	57
September	$35\frac{7}{8}$	282	8,324	50
October	$45\frac{7}{8}$	242	8,904	48
November	$56\frac{1}{3}$	223	9,628	52
December	$52\frac{1}{3}$	196	7,540	32
Total	....	3,151	89,756	558

WELLS COMPLETED IN EASTERN ILLINOIS FIELDS IN 1909.

County.	Completed	New Production, bbl.	Dry Holes.	County.	Completed.	New Production, bbl.	Dry Holes.
Crawford	2,093	44,379	355	Cumberland	33	558	10
Lawrence	724	41,056	56	Edgar	6	10	4
Clark	181	3 219	47	Miscellaneous	102	439	83
Coles	12	95	3	Total	3,151	89,756	558

There was considerable "wildcatting" during the year, especially along the western edge of the great structural basin of southern and central Illinois. The territory around St. Louis, in Green, Jersey, Macoupin, Madison and St. Clair counties, was sparingly drilled, but with poor results. At Waverly, in Morgan county, a small show of oil was obtained. During the latter part of 1909 there was considerable activity in the central-southern part of the State, and especial attention was given to the anticlinal structure at DuQuoin where conditions are favorable to the accumulation of oil.

The finding of oil at Sparta in 1906 occasioned considerable drilling in Randolph county. A small production was secured in 1908, but decreased during 1909, and at the present time the field is all but abandoned. The oil comes from the Chester formation, which here rises rapidly to the west until it outcrops five miles from Sparta. This is the same formation which contains the deep producing sands of the main field. Oil was found in small quantities at Eldorado, in Saline county. Three wells near Sandoval, in Marion county, were brought in during the year. This caused an unusual activity in that section of the State. and as a result there was a wholesale leasing of farms in all directions with a considerable loss through payment of exorbitant bonuses. The producing area at the present time seems to be limited to about 300 or more acres of ground. The sands in which the oil occurs are in the Chester formation, and apparently corresponds to the Buchanan and Kirkwood sands of the main field. The initial output of wells averaged about 125 bbl. From the standpoint of production the year, as a whole, was prosperous, and if adequate shipping facilities were available the outlook for 1910 would be excellent. The use of oil as fuel is receiving attention in the Illinois field, and since the production of gas is decreasing, this new use is destined to be an important one.

Indiana and Ohio. (By Harold C. George.)—The output of the northwestern Ohio and the eastern Indiana oilfields has declined steadily. The total production in 1909 was 6,192,000 bbl., as compared with 7,287,000 bbl. in 1908, and 8,030,000 bbl. in 1907. Twelve thousand wells have been abandoned during the past five years and the production has been maintained only by the constant drilling of new wells. These wells have not been abandoned on account of the scarcity of gas nor the large volume of salt water, but because they no longer produce oil. In other

PRODUCTION OF WELLS DRILLED IN THE LIMA FIELD IN 1907, 1908 AND 1909.

Field.	Number of Wells Drilled.			Daily Production in Barrels.			Daily Production in Barrels per Well Drilled.			Per Cent. of Dry Holes.		
	1907	1908	1909	1907	1908	1909	1907	1908	1909	1907	1908	1909
Northwest Ohio.....	930	837	917	8,100	9,252	7,771	8.7	11.0	8.4	15	9	9.6
Northeast Indiana..	682	413	304	5,673	3,405	3,852	8.3	8.2	12.6	20	19	27.3
Total..........	1,612	1,250	1,221	13,773	12,657	11,623	8.5	10.1	9.5	17	13.5	14.0

words, the oil-bearing formation has been drained. The percentage of dry holes drilled during 1909 increased, as is shown in the accompanying table, which gives only the new wells and their production. The average price paid for North Lima oil in 1909 was 91½c. per bbl. as compared with \$1.03 in 1908, and 93½c. in 1907. South Lima oil has brought 5c. per bbl. less in each of these years.

Ohio. (By J. A. Bownocker.)—The petroleum industry in Ohio was unusually quiet in 1909. No large pools and but few small ones were discovered anywhere in the State. Along the western edge of the Steubenville field a small deposit was found in the Berea sand, but the limit of the producing territory was soon reached. Several still smaller pools were found in the southeastern part of the State. So extensively has that territory been tested that no large discoveries can be expected. In 1907 oil was found in the Clinton sand in Fairfield county, and many felt that a large reservoir had been tapped. Many strings of tools were set at work but the results have not been in proportion to the time and money expended. Many of the wells are approximately 3000 ft. deep. Work is still in progress. Efforts have been made in neighboring counties to discover oil in the same formation, and while oil has occasionally been found, the quantity secured has been small and the number of dry holes large. The Trenton limestone field of northwestern Ohio had still less notable a year. Very little drilling was done and no real extensions to the territory were made. This field has reached the stage where the wells abandoned outnumber those drilled. The producing acreage is now at a maximum, though the oil production is much less than formerly. Henceforth reports on this field will be that of a declining industry.

Kansas and Oklahoma. (By Erasmus Haworth.)—Probably the most interesting development in the mid-continental field during 1909 was the bringing in of a new pool six miles north of Okmulgee, at Hamilton. In August a well was drilled which had an initial flow of 800 bbl. per day. Five other wells, each of which is a good producer, were drilled, the last one starting off with a natural flow of 1500 bbl. The discovery at Hamilton created quite a furor among oil men. The wells are the deepest of any in the entire field, with the possible exception of a few outside ones in remote districts. The sand lies uniformly 2200 ft. deep and is what practical oil men call a "fine" sand. No large gas wells were obtained, but a steady flow for months with but slight cessation means that there is sufficient gas to produce strong-flowing wells. Further, no one shot any of the wells. By the first of December there were more than 40 rigs on the ground. The Hamilton pool lies almost immediately south of the famous Glenn pool which makes it in line with practically all the great producers from Dewey south by way of Bartlesville and Red Fork, one of the most remarkable oil trends in the world.

Some drilling was done throughout the entire mid-continental area, but the amount was in no wise comparable with that of other years. The production already obtained was more than the markets demanded which accounts for a lapse of drilling activities. In the vicinity of Muskogee a number of wells were obtained all of which produced the same high-grade oil as of earlier times. Two well-defined oil sands are encountered here, one at about 1200 ft. and the other at about 1600. The oil in the upper has an average gravity of about 42 deg. B. and in the lower of about 38 deg. Baumé.

The shallow field in the vicinity of Alluwe and Coody's Bluff remained productive to such a degree that some optimistic operators figure that this field could produce 100,000 bbl. daily should the market call for it. As Nowata is the principal town in this vicinity, it is becoming customary to speak of the region as the Nowata area, although the oil is obtained to the east and northeast of this place.

No new pipe lines were built during 1909 to carry oil outside the mid-continental field, but those in existence were in use all the time. The Prairie Oil and Gas Company purchased from 70,000 to 90,000 bbl. daily throughout the year, nearly all of which was delivered to the pipe-line companies, leaving but a small portion to be put in storage as will be seen by an examination of the statistical tables hereto appended. The Texas Pipe Line Company and the Gulf Pipe Line Company each shipped large quantities of oil throughout the year. The Standard Oil Company began work on a large pipe line from the mid-continental field

OIL PRODUCTION, MID-CONTINENTAL FIELD, DURING 1909.

	Bbl.		Bbl.
Prairie Oil and Gas Company	28,726,196	Independent refineries	2,975,000
Texas Oil Company	6,250,000	Fuel oil, crude	500,000
Gulf Oil and Pipe Line Company	7,375,000	Independent shippers	1,000,000
Total for year			46,826,196

to the gulf. One branch of this line will start from the vicinity of Nowata and one from the Glenn pool. The two will meet a little northwest of Muskogee, from which point the line will be carried through Arkansas and Louisiana by way of Baton Rouge, where the Standard Oil Company is building a $2,000,000 refinery. It is hoped by producers that, with the construction of this new line, a much greater demand for oil than has existed for the last two years will result.

The great bulk of oil produced in the mid-continental field was refined by the Standard Oil Company. Most of the independent refineries were in operation during the year, although some of the lesser ones were idle the greater part of the time. A larger amount of fuel oil was consumed in 1909 than ever before in the history of the mid-continental field. Much more than one-half of the oil thus consumed came from the refineries, yet a comparatively large amount of crude oil was taken directly from the wells to the furnaces throughout portions of Texas, Oklahoma, Kansas and Nebraska. The large refinery at Sugar creek near Kansas City supplied the greater portion of the oil consumed. This refinery gets its supply of crude oil entirely from the mid-continental field.

CRUDE OIL BOUGHT BY PRAIRIE OIL AND GAS COMPANY DURING 1909.

Month.	Total Runs, Bbl.	Daily Average, Bbl.	Deliveries, Bbl.	Stored, Bbl.
January	2,684,529	86,597	2,197,351	487,178
February	2,322,582	82,949	1,804,899	517,683
March	2,449,129	79,004	2,178,254	261,875
April	2,294,894	76,496	2,262,918	31,975
May	2,379,196	76,748	2,296,896	82,300
June	2,442,487	81,416	2,117,482	325,004
July	1,871,792	60,380	1,743,330	128,462
August	2,528,107	81,551	2,492,897	35,210
September	2,516,956	83,898	2,405,133	111,822
October	2,382,488	76,854	2,369,525	12,963
November	2,459,353	78,978	2,425,499	33,854
December	2,394,683	78,897	2,209,459	9,393
Total	28,726,196		26,503,643	2,037,719

Montana-Wyoming.—The Frannie-Garland oilfield is situated in Northern Wyoming and Southern Montana on the western slope of the anticline of the Big Horn and Pryor mountains and about 20 miles from the mountains proper. Until early in 1909 this district attracted but little outside attention and development work was carried on entirely by local people. Of late, however, oil men from California, Kansas, Oklahoma and the East have become active in the field. The formation is principally shales and sandstones, the upper sandstones being coal-bearing. The oil is of fair quality and has a specific gravity of 0.8315. It contains no sulphur and boils at 77 deg. C. Distillation of a sample gave the following results: Naphtha (sp.gr. 0.722), 14 per cent.; illuminating oil (sp.gr. 0.761), 28 per cent.; light lubricating oil, 17.5 per cent.; residue suitable for cylinder oil, 36 per cent.; loss, 4.5 per cent. The absence of artesian flows of water and the nature of the formation makes easy drilling quite certain. In favored localities it is estimated that the oil sands will be reached at a depth of from 600 to 900 ft. and in other places at depths of from 1000 to 1500 ft. In the south end of this field the Montana-Wyoming Oil Company brought in three flowing wells variously estimated as yielding from 300 to 500 bbl. per day. A refinery is projected to treat the oil from this district and some of the equipment is now on the ground at Cowley where the refinery is to be situated. The Burlington railroad runs through the heart of this field furnishing ample transportation facilities.

Oregon.—The oil possibilities of Malheur county, Oregon, are being investigated by several companies. Large bodies of oil sands and shales are exposed in the district. A number of wells have been sunk, and oil mixed with water has been found at a depth of 1100 ft. in a well near Vale.

Texas and Louisiana.—Development in Texas and Louisiana during 1909 did not open up any new gusher pools, consequently production declined materially. Anse Le Butte, Markham, and Goose creek dwindled into small and costly pools confirming the opinion of most operators. Drilling at Piedras Pintas, the Mission and other fields, that at first gave promise of a reasonable output, were only conclusive in proving them to be of small area and limited capacity. Operations in the Caddo region were unsatisfactory on the whole and the production much less than anticipated. The proven area of the old pools was extended little, the field work consisting largely in cleaning out and deepening old wells. Salt water increased greatly in the majority of the

PRODUCTION OF LOUISIANA AND TEXAS. (*a*)
(In barrels of 42 gal.)

	Texas.			Louisiana.		
Year.	Production.	Value.	Avg. value per bbl.	Production.	Value.	Avg. value per bbl.
1896	1,450	$ 1,050	$0.720	....	....	....
1897	65,975	37,662	.570	....	....	....
1898	546,070	277,135	.508	....	....	....
1899	669,013	473,443	.708	....	....	....
1900	836,039	871,996	1.043	....	....	....
1901	4,393,658	1,247,150	.284	....	....	....
1902	18,083,658	3,998,097	.221	548,617	$ 188,985	$0.344
1903	17,955,572	7,517,479	.418	917,771	416,228	.453
1904	22,241,413	8,156,220	.367	6,718,958	2,438,952	.363
1905	28,136,189	7,552,262	.268	8,910,416	1,601,325	.180
1906	12,567,897	6,565,578	.522	9,077,528	3,557,838	.392
1907	12,322,696	10,401,863	.844	5,068,425	4,114,561	.812
1908	11,217,155	6,730,298	.600	5,573,144	3,455,349	.620
1909	9,256,972	7,220,438	.780	3,224,363	2,257,054	.700
Totals	138,293,757	$61,050,671		40,039,222	$18,030,292	

(*a*) From *The Oil Investors' Journal.*

pools, particularly at Spindle Top, Humble, and Jennings. The latter pool was especially disappointing and the output was less than half that of 1908 when it produced a much larger yield than any other coastal pool. While field conditions were uniformly discouraging crude-oil prices were fully up to expectations because local consumption exceeded the production.

The 1909 production of Texas, as nearly as it is possible to estimate, was 9,256,972 bbl., of which 8,765,000 bbl. were credited to the coastal field. The Louisiana estimate was 3,224,363 bbl., making the total output of the coastal region 11,989,363 bbl. The figures given indicate a decline of 1,960,183 bbl. in Texas (practically all in the coastal field) and 2,348,781 in Louisiana, every large pool showing a decrease except Caddo. The total value of the crude product was, however, only about $750,000 less than in 1908 for the average price per bbl. was about 15c. higher. The Humble pool was the largest producer in 1909, with a production of over 1,000,000 bbl. greater than that of Jennings, which was the leader in 1907 and 1908. The yield of the Gulf coast fields for a number of years is given in the accompanying table.

PRODUCTION OF GULF COAST FIELDS (*a*).
(In barrels.)

District.	1906	1907	1908	1909
Spindletop	1,077,492	1,699,943	1,741,070	1,388,107
Sour Lake	2,156,010	2,353,740	1,580,655	1,651,545
Saratoga	2,182,057	2,130,928	1,700,968	1,206,113
Batson	2,289,507	2,164,453	1,584,500	1,206,213
Humble	3,571,445	2,929,640	3,777,316	3,183,822
Dayton	92,850	108,038	39,901	17,647
Matagorda	8,000	4,500	2,000	1,800
Hoskins Mound	72,591	12,000	15,875	49,200
San Antonio (Mission field)	....	5,000	5,000	....
Markham (*b*)	....	....	60,869	28,574
Piedras Pintas	....	8,354	16,019	19,400
Corsicana	332,622	226,311	211,335	146,905
Powell	763,221	596,897	398,649	233,037
Henrietta	111,072	83,260	82,639	....
South Bosque	1,300	8,000	....	....
Jennings	9,025,174	4,895,905	4,856,889	2,170,454
Welsh	23,996	47,316	31,555	26,640
Anse La Butte	23,708	76,938	184,763	42,043
Caddo	4,650	48,266	499.937	985,226
Goose Creek (*b*)	....	....	11,160	12,746

(*a*) *Oil Investors' Journal.* (*b*) New field in 1908.

The daily runs of the coastal field in 1908 averaged 44,131 bbl., while in 1909 the daily average declined from 39,000 bbl. in January to less than 31,000 bbl. in December. It is difficult to estimate the stored coastal crude, but it was probably not in excess of 1,500,000 bbl. on Dec. 31, nearly all of which was held by refinery interests and not available for general consumption. According to the *Oil Investors' Journal* the total number of completed wells in 1909 was 719, of which 470 were oil producers, 28 gas wells and 221 dry holes. The completions in 1908 were 833, which shows a reduction of more than 200 wells in 1909.

In addition to the large decrease in number the average initial well capacity was less than half that in 1908. Sour Lake and Caddo were the only pools that showed increased activity. Batson, Humble, Spindletop and Jennings had the largest proportion of dry holes, Saratoga and Sour Lake the smallest. The number of wells drilled at Jennings was only half as large as in 1908 and dry holes were nearly as numerous as producing wells. In north Texas the Corsicana field was inactive, but the number of wells finished in the Powell and Henrietta pools was more than double that of 1908.

The record of completed wells does not include any outside the well-known pools. Wildcat drilling was undertaken in about 25 counties in Texas and 11 parishes in Louisiana extending over a wide area. A few wells made a small showing, but the only one of prominence was a well near Electra in Wilbarger county, northern Texas. It was finished late in the year and is said to be capable of producing 40 bbl. of 41 deg. B. oil from a sand found at 1200 feet.

The market for crude was weak early in January, prices at most points averaging 56c., with Caddo light selling at 50c. and heavy at 40c., Corsicana light at 70c. and fuel oil at 48c. In February when it was realized that the production was declining much below consumption, posted credit-balance prices advanced 2c. and spot oil at Jennings brought as high as 70c. The advance continued during March and April when credit-balance prices ranged from 72@76c. and Caddo oil brought from 50c. for fuel oil to 60c. for light grades suitable for refining. The market remained stable but inactive until July when the credit-balance prices stiffened to 75c. and remained unchanged to the end of the year, some oil selling as high as 80c. on contract, and spot oil a few cents higher. The stable prices indicate that the market in all portions of the territory adjacent to pipe lines or refineries is now dominated by the cost of Oklahoma crude. A considerable portion of the fuel-oil demand was satisfied by refinery residuum and consumption would be large if more tank cars were available. The stability of prices and the ability to obtain long-time contracts may increase the consumption, which undoubtedly declined owing to the high price and disinclination of coastal producers to make contracts guaranteeing price and delivery. The average posted credit-balance price for 1909 was 70@71c. in the coastal fields except Caddo, where the average was 50@55c.

The Standard Oil Company was constructing a refinery near Baton Rouge which, when completed, will have a still capacity of 10,000 bbl. The capacity of the Texas Company plant at Dallas was increased by 4800 bbl. daily and the Texas City Refining Company put in operation a new 2000-bbl. plant on the bay shore opposite Galveston. The Security Oil Company refinery near Beaumont was idle part of 1909 and the plant of the United Oil and Refining Company at Spindletop was closed down in August owing to financial difficulties which necessitated the appointment of a receiver.

Competition in refined products was very keen in 1909 and consumers had no reason to complain of prices or quality. Water shipments from Port Arthur and Sabine increased about 50 per cent. over those of 1908. Practically all the refinery products (except asphalt) were derived from Oklahoma crude and the bulk of the crude shipped was from coastal field. New pipe-line construction in Texas was generally for the purpose of increasing the facilities for tranferring Oklahoma crude. The Gulf Pipe Line Company completed a 6-in. line from Sour Lake to Houston in order to save freight rates in supplying fuel oil to south Texas points. In Louisiana various laterals were laid in the Caddo field and a portion of the Standard Oil line from Oklahoma to Baton Rouge was completed.

The injunction and seizure of tank cars in the action under the anti-trust laws against the Security Oil Company, Navarro Refining Company and the Union Tank Line Company made it difficult to obtain an adequate supply of crude and prevented shipment of refined products by these concerns. When the action was tried the Security Oil Company and Navarro Refining Company admitted that their products were sold, under agreement, exclusively to the Standard Oil Company. Judgment was pronounced fining them, ordering their charters canceled and perpetually enjoining them from doing business in Texas. The Union Tank Line Company was fined $75,000 and their cars in custody ordered sold. In the case of Texas vs. Waters-Pierce Oil Company the Supreme Court of the United States confirmed the State court on all points, a receiver was appointed, judgment given for ouster and a fine of $1,623,900 with costs imposed. The large fine was duly paid to the State Treasurer, the property sold in December to interests friendly to the defendants and the company will be reorganized.

Sour Lake, the only pool showing an increased output over that of 1908, was the center of interest in the early part of the year on account of the development of the deep sand on the south side of the field. The field was also extended slightly to the northeast and the monthly production increased to 175,000 bbl. These extensions failed to maintain their yield, however, and the production declined to 125,000 bbl. in November. While the Humble pool retained its position as the largest producer in Texas its output declined 600,000 bbl. and well completions were 63 less than in 1908. Salt water proved a serious problem to contend with in the deep sand of the northern extension and operators were satisfied with 100-bbl. wells in the 900-ft. sand. The situation is best shown by the fact that the average initial capacity per well declined from 215 bbl. in 1908 to about 60 bbl. in 1909. Spindletop and Batson were featureless with output diminishing slowly but surely. The Saratoga pool was extended a short distance south and southwest. It yielded 500,000 bbl. less than in 1908, but the monthly reports show that its production varied little during the year and that the proportion of dry holes was very small. At Markham the Producers Oil Company abandoned the field after expending $150,000 in obtaining an insignificant production. Goose Creek had only one producing well at the end of the year and the production in the Mission Field, Bexar county, and at Piedras Pintas, Duval county, remained nominal. Hoskins Mount in Brazoria county developed several good wells and, while the shipments to date have been comparatively small, the pool showed more promise of an increased output than any of the new districts.

The Welch field continued to give a small yield from old wells. All efforts to extend the Anse Le Butte pool were failures and the November production was only about one-third of that of January. The most disappointing feature of the year was the enormous decline in production at Jennings where about 50 wells were completed and the initial capacity of the producers was absurdly small when compared with previous years. A reduced yield was anticipated but not a decline of 2,686,435 bbl.

While the proven area in the Caddo field was largely extended in spots, field operations were not nearly as extensive as expected, though double what they were in 1908. The total yield was 485,289 bbl. in excess of 1908. The territory is apparently spotted and the wells vary greatly in capacity and in quality of crude. The producing wells are in the vicinity of Lewis, Vivian, Mooringsport, Oil City, Pine Island, and Hart's Ferry. Vivian, the most northerly pool (eight miles north of the regular deep sand) not only produced heavy oil, but some extremely large gas wells. These oil and gas wells are in the shallow sand and cost much less to drill than in other Caddo pools. Many of the outside tests resulted in dry holes, but the largest well of the year was brought in during November, two miles from the Texas line. This well, which is four miles from the nearest well in the deep sand, is said to be 2350 ft. deep and to have had an initial capacity of 2000 bbl. of 41-deg. B. oil.

Utah.—In 1909 the Utah Oil Refining Company started construction of a refinery at Salt Lake City. The plant will be capable of treating 100,000 gal. of crude oil per week, and is being built primarily to handle the product of the Pittsburg & Salt Lake Oil Company, which owns 15 wells in the Spring Valley oilfield in Wyoming, besides large deposits of hydrocarbons in the Uintah region in Utah.

(By Percy E. Barbour.)—The Rangely oilfields in Uinta county, on the border between Utah and Colorado, contain about 50 wells. None of these wells flow, but by pumping they furnish from 5 to 100 bbl. per day. The Denver Northwestern & Pacific railroad will pass within a mile of the Rangely field, and will give a great impetus to operations there. In San Juan county, in the extreme southeastern corner of the State, are other extensive oil lands. This district is at present greatly handicapped by its distance from the railroads, but a pipe line and two railroads have been surveyed into the fields which are about 50 miles wide by 90 miles long. There were 16 producing wells, one of which has produced by pumping 600 bbl. of oil per day. The oil-bearing sedimentaries have a thickness of about 3000 ft. The oil has a paraffin base. All the unlocated oil lands in this district were withdrawn from entry in 1909.

The Virgin oilfield in Washington county in the extreme southwestern corner of the State was the scene of considerable oil excitement, but the oil, encountered at a depth of 500 ft., was in small quantities. At a depth of 600 ft. a hard limestone was struck, which discouraged further work. However, some companies continued prospecting, with the result that the 400 ft. of limestone was penetrated and the shale underneath yielded oil. Underneath this shale brown oil sands occur for a thickness of about 200 ft. The Virgin oil has a density of 25 to 30. Surface indications in several other counties gave promise of oil and attracted the attention of Eastern oil men who did a large amount of reconnaissance work in the various prospective fields.

Petroleum in Foreign Countries.

Canada.—The production of petroleum in Canada in 1909 amounted to less than 15,000,000 gal. as compared with 18,479,547 gal. in 1908. The output was, as usual, nearly all derived from the Ontario peninsula. Direct returns from the producers have not been obtained, but the production upon which bounty was paid was 14,726,433 gal., of which 3328 gal. were produced in New Brunswick. This is equivalent to 420,755 bbl. and at an average price of $1.33 per bbl. was valued at $559,604. The total bounty paid in 1909 was $228,896. The decrease in output was partly caused by the slight diminution annually going on in the old fields of Lambton county, and partly by the more rapid falling off in the production of the wells of the newer Kent county field in Ontario. Besides the oil centers of Petrolia and Oil Springs in Lambton county and the Kilbury field in Kent county, other occurrences are at Bothwell and Coatswort in Kent, Stutton in Belgium, Leamington in Essex, and Moore in Lambton counties. The oilfields are all situated within an area underlain by Devonian strata, and the petroleum is largely obtained from the Onondaga formation. At Petrolia the oil-bearing horizon is generally not deeper than 450 ft. and at Bothwell it is about 600 ft. In places small quantities of oil have been obtained from the Trenton formation, while at Leamington the pool was found in the Guelph formation at a depth of 1075 ft. When first drilled the wells are often gushers, but upon the diminution of the pressure the oil has to be pumped. While some of the smaller districts become exhausted in a few years, others continue to furnish oil for a long period. The Lambton field is remarkable in this respect and though the average yield is small, the district still continues to produce a large amount of oil. Some wells have been active producers for forty years.

During 1909 the American-Canadian Company began active development work in the Alberta oilfield. This district is about 400 miles northeast of Edmonton and at present is inaccessible as there are no railroad facilities nearer than Edmonton. The Waterways and Athabasca Railway is building a road into the district and it is expected that the line will be completed in about three years. Oil has been found at a depth of about 2500 ft. and of the 14 wells already sunk eight have been commercial producers. The Dominion government has spent $30,000 in an investigation of the field. At the present time about one-half of the requirements of the Canadian refining trade are supplied by importation of crude oil from the United States.

Egypt.—During 1909 a good well was brought in at a depth of 1290 ft. on the coast of the Red Sea, south of Suez, by the Egyptian Oil Trust, Limited. This is the first well in Egypt to make a production, and the discovery is of importance, as the new field is upon one of the chief waterways of the world. The Egyptian government is making surveys with a view of granting concessions.

Galicia.—The production of crude oil in the Galician fields in 1909 was 2,150,000 metric tons, which is a record figure. Of this amount 1,740,000 tons were produced at Tustanowice and 236,467 tons at Boryslaw. Prices, which were approximately 8s. per ton at the beginning of the year, increased steadily, until in December they were over 16s. per ton. This advance was principally due to the fact that the State bought large quantities of crude oil. As the number of new wells and production is constantly increasing, there is a probability that a decline from these high figures will shortly take place, especially as competition with American companies is acute. The vital point of the Galician petroleum industry is that of storage accommodations. The increase in stock in the Boryslaw and Tustanowice fields in 1909 amounted to 510,400 tons, or almost one-quarter of the total production. The total stocks at the end of the year were 1,550,000 tons. In 1909, the State voted a considerable sum for tank construction, and a great number of tanks were erected, so that the increase in stocks lead to no such disastrous fluctuations in prices as has previously taken place with an increased production. At the close of 1909 there were 97 producing wells in the Tustanowice field and 36 in the Boryslaw district. As regards the future of the Galician oil industry, the most important question is that of the conclusion of an agreement among the producers for the control of prices and output.

PRODUCTION OF BORYSLAW-TUSTANOWICE FIELD.
(In metric tons.)

Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.	Year.	Tons.
1900..	55,000	1902..	226,000	1904..	546,000	1906..	562,000	1908..	1,585,620
1901..	132,000	1903..	373,000	1905..	546,500	1907..	1,011,500	1909..	1,976,467

India.—The production of petroleum in India in 1909 may be estimated at 200,000,000 gal., as compared with 176,646,320 gal. in 1908. Five-sixths of the total output came from Burma where the most productive fields are situated to the east of Arakan Yoma in the Irrawaddy valley. At present the best-known and most extensively developed field is at Yenangyaung, the average daily output from this district being about 15,000 bbl. There are other newer fields which are producing oil in constantly increasing quantities, notably the ones at Singu and Yenangyat. Considerable oil is still obtained from wells dug by native labor, but the principal output is from wells drilled with modern machinery. A royalty is paid to the government of 16c. per 100 viss (365 lb.), in the case of early leases, and 16c. per 40 gal. for later leases. Pipe line systems to handle the oil have been installed. One of these, 45 miles long, connects the fields at Singu and Yenangyat with Yenangyaung, and one, 275 miles long, joins Yenangyaung and Rangoon. This latter line will materially lessen the cost of transporting oil from the fields to the refineries. In 1909 five companies were refining petroleum in Burma.

In the Punjab, the districts in which petroleum has been found are Shapour, Thelum, Bannou, Kohat, Rawalpindi, Hazara and Koumaoun. The production is still very limited, only reaching one or two thousand gallons per year. Explorations in Beluchistan have proved an abundance of oil of very good quality near Khotan and Moghal Rot. In Assam the petroleum-bearing areas are situated: (1) at Tipam Hill to the north of Ditring; (2) in the country between Ditring and Disang; (3) in Makoum between the rivers Dirak and Tirap. The outlook in the last-mentioned district is very encouraging and points to a profitable and extensive development. The production of petroleum in Assam in 1909 amounted to about 10,000,000 gal. An import duty of one anna per gallon is charged on petroleum coming into India.

Japan.—In 1908 Japan produced 65,165,860 gal. of crude oil, which was principally obtained from the province of Niigata. The other oil-bearing districts, with the exception of Taiwan, are as yet of small account. Although the production of oil in Japan is growing rapidly, the domestic demand is increasing at a much more rapid rate, and large quantities of petroleum products are imported. In 1908 imports of kerosene amounted to 216,623 tons, and the domestic production to 99,976 tons. About 60 per cent. of the total quantity of imported iluminating oil is of American origin, and about 25 per cent. comes from Russia.

Mexico.—Owing to lack of complete statistics it is impossible to give any reliable data as to the petroleum production of Mexico, but it may be estimated at approximately 3,000,000 bbl. in 1909. Extensive development work was carried on during the year, but results as to production were not altogether encouraging. The lack of railroad and other transportation facilities served to retard developments, and many good wells are now capped awaiting a means of getting the oil to market. The Doheny interests, which control the Mexican Petroleum Company and the Hausteca Oil Company, are the largest producers in the country. Other producing companies are the Compania Mexicana Petrolea el Aguila, including the interests of S. Pearson & Son, Oil Fields of Mexico, Ltd., Mexican Fuel Oil Company (Waters-Pierce Oil Company), and the East Coast Oil Company (Southern Pacific Railroad). All these concerns made considerable progress in 1909 and the results obtained demonstrated that Mexico is capable of developing a large supply of oil, perhaps sufficient for her own consumption, but at present it is safe to say that all the oil in sight will not supply the domestic demand.

The oil refining business in Mexico is confined chiefly to the Pearson interests, which operate a large plant at Minatitlan, on the isthmus of Tehuantepec, and the Waters-Pierce Oil Company, whose plant is located at Tampico. The latter company also has small refineries at Vera Cruz and Mexico City, but these plants have been out of commission for several years. During 1909, a commercial war was waged between these two concerns for control of the trade, and the prospects are that there will be a consolidation of these interests at no very distant date. The Mexican Petroleum Company has a refinery at Ebano, about 50 miles from Tampico, but the plant is small and is not considered much of a factor in the refining business of the republic. A modification of the tariff laws so as to permit crude oil for refining to come in free of duty when any portion of it is to be exported, was adopted by the Mexican congress in 1909. This legislation is presumed to have been urged by the Pearsons, who are importing most of the crude oil run at their refinery.

The principal producing districts in Mexico are Tampico and Ebano in the State of Tamaulipas, and Tuxpan, Furbero, Dos Bocas, and San Cristobal in the State of Vera Cruz. The Tampico district was more extensively developed than any other in 1909, and several wells making 400 to 500 bbl. per day were brought in. In the Ebano district, practically owned by the Mexican Petroleum Company who control 480,000 acres, about 6000 bbl. per day were shipped, making this district the largest producer for commercial consumption in Mexico. Extensive drilling operations were carried on in the Tuxpan and Furbero districts, and in the latter field out of nine wells sunk, four came in as producers. S. Pearson & Son secured control of these Furbero wells by advancing money to build a pipe line, and railroad to Tuxpan, to afford a means of transporting oil from the field to tide water and carrying supplies from Tuxpan to the field. The railroad and pipe line would have been completed in 1909 had it not been for the torrential rains which washed away a section of both.

At Dos Bocas a well was struck by the Pearson interests, which was said to have been producing at the rate of 2500 bbl. per day when it went to water after the blowout in the now world-famous No. 3 gusher. At the end of the year No. 3 was still in eruption, making great quantities of water and gas and some oil. All efforts to save any of the oil were abandoned after hundreds of thousands of dollars had been spent. At the time of abandonment the cavity at the mouth of the well covered an area of 37 acres, and the well was making 1,000,000 bbl. of water and perhaps 2000 bbl. of oil per day, forming a river 100 ft. wide and 14 ft. deep. Careful estimates place the amount of oil which probably flowed from this well at 15,000,000 bbl. The deluge of salt water spoiled the field, and in September the Pearsons abandoned their wells and suspended all operations in this district. The San Cristobal and Conception fields at the close of 1909 were making less than 500 bbl. per day, which was piped to the Minatitlan plant of S. Pearson & Son for refining. Most of the oil refined in this plant is Oklahoma crude, which is shipped in from Port Arthur, Texas, at the rate of about 40,000 bbl. per month. At Macuspana, in the State of Tabasco, three wells were brought in and capped by the Indian Territory Illuminating Oil Company. A well of 400- to 500-bbl. capacity was reported during the year in the State of

Chiapas. Some oil explorations were carried on in the northern part of Chihuahua by the Hearst-Keene interests, but oil was not obtained in sufficient quantity to justify development.

The Mexican fields promise to yield large quantities of crude oil, but its quality is such that it cannot compete under present conditions in the markets of the United States or Europe with the higher-grade petroleum of the Appalachian, Illinois or mid-continental fields. Further, the conditions are such that the demand for fuel oil and refined products in Mexico exceeds the supply available at present, or in sight. Finally, conditions in the Mexican field are unfavorable to the small operator, and it is regarded as highly probable that production as well as refining will remain in the hands of a few strong companies.

Persia.—Much activity was shown in 1909 in developing oil prospects at the head of the Persian gulf. Productive wells were located near Awaz and on the Diala river in Kurdestan. Oil indications extend the full length of this belt, and in many places crude oil has been produced by the natives for their own consumption for many years. The Anglo-Persian Oil Company constructed a pipe line to connect the wells near Awaz with a refinery to be built at Mohammereh. Other oil deposits are said to exist around Khanikan near the Turkish frontier.

Peru.—Peru is the only South American country where oil has been found in large quantities. The present producing fields are those of Negritos, about 40 miles north of Paita; Lobitos, 60 miles north of Paita, and Zorritos, 30 miles south of Tumbez. Nearly all the wells exploited lie in the vicinity of the ocean, and the oil is often pumped directly into the transport steamer, so that the cost of exploitation is reduced to a minimum. The oilfields lie mostly in the northern part of Peru, near the frontier of Ecuador. The principal seaports from which the exploitation of oil takes place are those of Paita and Oalizada. In 1908 the production was 206,314 tons, as compared with 100,184 tons in 1907. The number of wells is increasing rapidly, and more than 700 were in operation in 1908. The Peruvian oil is of superior quality and is largely exported. Local consumption in 1908 amounted to only 12,310 tons.

Philippine Islands.—Petroleum has been found in five places in the Philippine archipelago—three in the Tayabas province, the other two on the island of Cebu; one on the west coast near Toledo and the other at Alegria. In Tayabas and in the first-named locality in Cebu some prospecting has been carried on, but the Alegria field as yet remains practically unknown. The oil in all three of these localities is found in a bluish shale, presumably of Tertiary age, and appears to be of very good grade. It has a paraffine base and in composition is similar to Sumatran oil. To date no commercial production has been made, but the apparent connection, between coal and oil deposits in Cebu and other islands of the group leads to the conclusion that in time oil may be found in paying quantities in many parts of the archipelago.

Rumania.—In 1909 the output of petroleum in the Rumanian fields amounted to 1,296,403 metric tons, an advance of 148,676 tons over the production in 1908. A large part of the increase was obtained by the exploitation of the Tintea field which had been neglected for some years. The Campina and Moreni fields made good productions and will undoubtedly play important parts in the future development of the Rumanian oil industry. Of the total production in 1909, 1,107,825 tons, or 85.4 per cent., were refined, producing 41.9 per cent. of benzine, kerosene and distillate, 3.9 per cent. of light lubricating oils and 52 per cent. of residuum. The loss in refining was 2.2 per cent. Exports for the year amounted to 49,715 tons of crude oil, residuum and light lubricating oils, 261,237 tons of kerosene and distillate, 108,218 tons of benzine and 545 tons of paraffine, a total of 420,115 tons. Among the important consolidations of the year was that of the Moreni property of the Regatul Roman Company and of the Astra Company into a new company under the name of the Astra-Romana. The formation of this company means the establishment on the Rumanian market of the great Dutch company Koninklyke which apart from the Standard Oil Company is the most powerful petroleum trade organization in the world. The establishment of an *entente* between the refiners is one of the greatest needs of the Rumanian oil industry. Without an agreement of some sort Rumanian producers cannot hope to obtain satisfactory prices in foreign markets where American and Galician competition have reduced prices to a minimum. Even in the domestic market the competition between local refiners was very bitter and a working agreement would do much toward stopping the depreciation in the prices.

PRODUCTION OF PETROLEUM IN RUMANIA.

Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.	Year.	Metric Tons.
1898.......	180,000	1901.......	270,000	1904.........	500,561	1907.........	1,129,097
1899.......	250,000	1902.......	310,000	1905.........	614,870	1908.........	1,147.727
1900.......	250,000	1903.......	384,302	1906.........	887,094	1909.........	1,296,403

Russia.—The production of crude oil in Russia in 1909 amounted to 490,700,000 poods, an increase of 24,300,000 poods over the output in 1908, and more than in any year since 1904, when the production was 614,600,000 poods. In spite of the progress made during 1909, the Baku fields which practically supply the entire Russian output are producing less crude oil today than they were 10 years ago. Prices remained fairly even throughout 1909. The year opened with crude oil at about 21 copecks, and residuum at 21¼ copecks per pood. Prices rose as usual during the open navigation season, until in June 23 copecks per pood was reached after which prices sank to 18½ copecks, at which figure they closed at the end of the year. The average price of crude oil for the year was about 21 copecks per pood, which is about one copeck below the average of 1908.

In the Baku field, the production was small at the beginning of the year, but after February it increased steadily and during the last six months was greater than for several years past. A marked feature was the increased yield of wells situated in old oil territory at Balakhani, Sabunchi and Romani. In 1909 the quantity of spouted oil amounted to 18,900,000 poods, or 5.1 per cent. of the total production, while in the four preceding years it did not exceed 3.3 per cent. Activity in the Surachany field increased and 1,312,619 gal. of white oil, and 7,709,465 gal. of dark crude oil were produced.

The number of wells brought in in 1909 was 208, as compared with 271 in 1908, but the 1909 production showed an increase. This, however, may be accounted for by the fact that during 1908 there were incessant labor troubles, from which 1909 was completely free. In 1909 only 182 new wells were commenced as compared with 217 in 1908, which means a correspondingly less number of wells will be brought in in 1910. A continued increase in production should not, therefore, be expected.

On Nov. 30, 1909, the council of Baku naphtha producers made representations to the Minister of Finance at St. Petersburg, requesting a reduction in the railway tariff on kerosene and in the State pipe-line rates. The tariff for the transport of kerosene from Baku to Batoum is 19 copecks per pood, to which must be added 2 copecks per pood for local port and other expenses. The cost of kerosene at Baku during 1909 ranged from 25 to 32 copecks per pood, consequently in exporting kerosene from Russia to the United Kingdom at 40 copecks, exporters lost several copecks per pood. Hence the enormous decline in exports of Russian illuminating oils. A reduction in the charge for pumping oil through the State pipe line would enable Russian producers and exporters to renew business with British and continental importers, and would increase the revenue derived from the pipe line, which has for several years past been working at less than half capacity. The trade interests demanded immediate action and a meeting of the tariff committee at St. Petersburg was called for the purpose of revising the existing rates on the Trans-Caucasian and Vladikavkaz railways for oil carried from Baku to Batoum, and from Petrovsk to Novorossisk.

At Grosny the crude oil production is increasing every year, the total production in 1909 amounting to 57,000,000 poods, as against 52,000,000 in 1908, or a gain of 5,000,000 poods, or nearly 10 per cent. In southern Russia the Maikop oil field came into prominence toward the end of 1909, when the Black Sea Oil Fields, Limited, brought in a gusher at a depth of less than 300 ft. Since that time operations have been carried on with great activity. This field embraces an area of about 25 miles long by about 20 miles wide at the point of greatest breadth. The Maikop petroleum is the most valuable in Europe, containing approximately 25 per cent. of benzine and 24 per cent. of kerosene.

At Binigady drilling operations continued, and the production of the year is estimated at 35,000,000 gal. Much attention was given to the island of Tehelleken, where oil and ozokerite were found. The oil is of very high quality, containing from 7 to 10 per cent. of pure paraffine. A large spouter which produced 5,250,000 gal. of oil was brought in and capped during the year. Boring activity continued on Holy Island, where several of the Baku companies took up claims. Attention was also given to a new field near Shemakha, about 40 miles from Baku.

OUTPUT OF OIL AT BAKU AND GROSNY FROM 1901 TO 1909.
(In millions of poods.)

	1901	1902	1903	1904	1905	1906	1907	1908	1909
Baku	671	636	600	615	410	448	476	467	491
Grosny	35	34	33	40	43	38	40		
Total	706	670	633	655	453	486	516	467	491

The quantity of petroleum products transported by the Caspian Sea to Astrakhan in 1909 was 1,221,805,410 gal., as against 1,140,121,955 gal. in 1908. The shipments of petroleum products from Batoum during 1909 amounted to 173,823,585 gal., as against 155,706,540 gal. in 1908. The bulk of the decrease in exports of oil during the past few years has been in the exports of kerosene to Far Eastern markets, which may now be said to be irretrievably lost to the Russian petroleum industry. In the consumption of oil as fuel Russia leads the world, using about 6,000,000 tons annually. The railways of Russia consumed 3,000,000 tons of oil in 1908, and only 5,000,000 tons of coal.

Trinidad.—During 1909 the exploration of the oilfields of Trinidad was carried on vigorously. The attention of investigators was particularly directed towards the southern half of the island, and reports from that region seem to indicate that a field from 500 to 800 square miles in extent will be proved. In all probability the oil-bearing region will extend below the Gulf of Paria and westward beyond the region of Pitch lake, to the Gulf of Maracaibo. Should all this territory prove oil bearing, this will be one of the largest oilfields in the world. It is stated that a dozen wells, from 800 to 1400 ft. in depth, have been sunk by a London company with satisfactory results, and that some are already excellent producers. An American company also has a number of wells, from 900 to 1400 ft. deep. Due to inadequate storage facilities, many thousands of gallons of crude oil have run into the sea, but storage capacity is rapidly being developed and in 1909 a 2,240,000-gal. tank was erected at La Brea.

Bibliography of Petroleum in 1909.

Anonymous. ''Commonwealth Oil Corporation, Ltd.'' (*Petrol. Rev.*, Jan. 16, 1909; 6 pp.)

Anonymous. ''Madagascar Oil Fields.'' (*So. Afr. Min. Journ.*, July 24, 1909; 1½ pp.)

Anonymous. ''Madagascar Oil Prospects.'' (*So. Afr. Min. Journ.*, Aug. 14, 1909; 1½ pp.)

Anonymous. ''The Moreni Oil Field of Rumania.'' (*Petrol. Rev.*, Sept. 25, 1909; 2 pp.)

Anonymous. ''The Oil Fields of Ferghana, Russian Turkestan.'' (*Petrol. Rev.*, Nov. 6, 1909; 2 pp.)

Anonymous. ''Oil Indications in South Africa. (*So. Afr. Min. Journ.*, Aug. 21, 1909; 1½ pp.)

Anonymous. ''Oil Prospects in Northern Nevada.'' (*Petrol. Rev.*, Jan 2, 1909; 1¼ pp.)

Anonymous. ''S. Pearson and Son's Uncontrollable Oil Gusher.'' (*Eng. and Min. Journ.*, Jan. 2, 1909; 3 pp.)

Anonymous. ''Recent Petroleum Developments in New Zealand.'' (*Petrol. Rev.*, Sept. 11, 1909; 1 p.)

Anonymous. ''The Roma Bore.'' (*Queens. Govt. Min. Journ.*, Jan. 13, 1909; 3¾ pp.)

Anonymous. ''The Petroleum Deposits at Kertch, Taman and Anapa.'' (*Petrol. Rev.*, Dec. 4, 1909; 2 pp.

Anonymous. ''The Petroleum Deposits in Russian Sakhalin.'' (*Petrol. Rev.*, Dec. 4, 1909; 1¼ pp.)

Anonymous. ''Texas Petroleum History.'' (*Mfrs. Rec.*, Jan. 21, 1909; 1 p.)

Anonymous. ''Yacimiento de Petroleo en el sur de Chile.'' (*Bol.* de la Sociedad Nacional de Mineria, Aug., 1909; 6 pp.)

Anderson, Robert. ''Two Areas of Oil Prospecting in Lyon County, Western Nevada.'' (*Bull.* No. 381-D, U. S. Geol. Surv., 1909; 4 pp.)

Anderson, Robert, ''Geology and Oil Prospects of the Reno Region, Nevada.'' (*Bull.* 381-D, U. S. Geol. Surv., 1909; 15 pp.)

Bain, H. Foster. ''Petroleum Fields of Illinois.'' (*Min. and Sci. Press*, July 31, 1909; 3½ pp.)

Barbour, P. E. ''The Los Angeles Oil Industry.'' (*Eng. and Min. Journ.*, Aug. 21, 1909; 1½ pp.)

BARRY, JOHN G. "The Bottineau Oil Field." (*Eng. and Min. Journ.*, May 29, 1909; 1 p.)

BASKERVILLE, CHARLES. "Economic Possibilities of American Oil Shales." (*Eng. and Min. Journ.*, July 24 and 31, 1909; 9½ pp.)

BECKER, G. F. "Relations between Local Magnetic Disturbances and the Genesis of Petroleum." (*Bull.* 401, U. S. Geol. Surv., 1909; 19½ pp.)

BLATCHLEY, R. S. "Drilling for Oil in Eastern Illinois." (*Min. and Sci. Press*, Nov. 6, 1909; 4¼ pp.)

BLATCHLEY, R. S. "Pumping and Shipping Oil in Eastern Illinois." (*Min. and Sci. Press*, Nov. 20, 1909; 3 pp.)

BOSTAPH, H. P. "The Oil Fields of Canada and Their Possibilities." (*Petrol. Rev.*, Oct. 23, 1909; 1½ pp.)

BOSTAPH, H. P. "Drilling and Equipping of an Oil Well in the Yilbury Oil Fields, Canada." (*Petrol. Rev.*, Dec. 4, 1909; 2 pp.)

CALDWELL, WILLIAM. "The Working of Oil Shale at Pumpherston." (*Trans.* Min. Inst. Scot., Vol. XXXI, Part 4, 1909; 8½ pp.)

COSTE, EUGENE. "Petroleum and Coals: A Comparison of Their Nature, Mode of Occurrence and Origin." (*Can. Min. Journ.*, May 15 and June 1, 1909; 10 pp.; paper read before Canadian Mining Institute.)

COTTER, G. DE P. "The Southern Part of the Gwegyo Hills, including the Payagyigon-Ngashandaung Oil Field." (*Rec.* Geol. Surv., India, Vol. XXXVII, Part 2, 1909; 9½ pp.)

DALTON, L. V. "A Sketch of the Geology of the Baku and European Oil Fields." (*Econ. Geol.*, Mar., 1909; 28 pp.)

DALTON, L. V. "The Origin of Petroleum." (*Econ. Geol.*, Oct.-Nov., 1909; 30½ pp.)

DAY, D. T. "Mexican Oil Fields." (*Petrol. Rev.*, June 5, 1909; 2 pp.)

DAY, D. T. "Analysis of Crude Petroleum from Oklahoma and Kansas." (*Bull.* 381-D, U. S. Geol. Surv., 1909; 10 pp.)

DAY, D. T. and GILPIN, J. ELLIOT. "The Changes in Crude Petroleum Effected by Diffusion through Clay." (*Journ. Ind. and Eng. Chem.*, July, 1909; 6 pp.)

DUNIKOWSKI, HABDANK. "Le Petrole dans l'Afrique du Nord." (*Journ. du Pétrole*, Nov. 15, 1909; 4½ pp.)

DVORKOVITZ, D. "The Petroleum Industry of Rumania." (*Petrol. Rev.*, Nov. 20, 1909; 1½ pp.)

EDELEANU, DR. "Comparison entre le Pétrol Roumain et des Pétrols Etrangers." (*Revue du Pétrole*, June 8, 1909; 3 pp.)

ELLS, R. W. "Bituminous Shales of Nova Scotia and New Brunswick; with Notes on the Geology of the Oil Shales of Scotland." (*Indust. Advocate*, May, 1909; 4¾ pp.)

ENGLER, C. "Origin of Petroleum." (*Am. Chem. Journ.*, Jan., 1909; 8 pp.)

FENN, R. W. "Calorific Value of California Fuel Oil." (*Eng. News*, May 13, 1909; 1¼ pp.)

FORSTNER, WILLIAM. "Geology of the Coalinga Oil District." (*Min. and Sci. Press*, Oct. 23, 1909; 1 p.)

HENDERSON, J. McC. "Les Concessions Pétrolifères Taylor-Coryell à Madagascar." (*Journ. du Pétrole*, June 1, 1909; 4 pp.)

HOSTY, H. C. "The Oil Fields of Tayabas." (*Philippine Resources*, Nov., 1909; 2 pp.)

KOBAYASHI, K. "On the Properties of Japanese Petroleum." (*Cal. Derrick*, Feb., 1909; 3¼ pp.)

Lakes, Arthur. "The Origin of Oil." (*Min. Sci.*, Aug. 12, 1909; 2 pp.)

Lakes, Arthur. "The Marine Organic Origin of Petroleum." (*Min. Sci.*, Oct. 16, 1909; 2¾ pp.)

Lidoff, A. P. "The 'Liming' of Crude Oils Before Distillation." (*Petrol Rev.*, Mar. 27, 1909; 2 pp.)

MacFarland, Ira. "Development in Petroleum in Nevada." (*Proc.* Am. Min. Congress, 12th annual session, 1909; 4 pp.)

Mazet, L. "Refining of Mineral Oils." (*Petrol. Rev.*, Nov. 6, 1909; 1¾ pp.)

Mrazec, L. "The Origin of Petroleum." (*Petrol. Rev.*, May 8 and 22, 1909; 2½ pp.)

Mrazec, L. "Classification of Petroleum Deposits." (*Petrol. Rev.*, June 19, 1909; 1 p.)

Munn, Malcolm J. "Studies in the Application of Anticlinal Theory of Oil and Gas Accumulation." (*Econ. Geol.*, Mar. and Sept.-Oct., 1909; 37 pp.)

Munn, M. J. "The Anticlinal and Hydraulic Theories of Oil and Gas Accumulation." (*Econ. Geol.*, Sept.-Oct., 1909; 21 pp.)

Murgoci, G. M. "Les Raffineries de Pétrole en Roumanie." (*Revue du Pétrole*, June 8, 1909; 2 pp.)

Osiceanu, C. "Rumanian Petroleum Industry from a General Point of View." (*Petrol. Rev.*, Oct. 9, 1909; 1½ pp.)

Peet, C. A. "Green River Oil Fields in Wayne County, Utah." (*Salt Lake Min. Rev.*, Dec. 30, 1909; 3 pp.)

Porn, M. "Betrachtungen uber die wirkliche Lage unserer Petroleum-Industrie." (*Revue du Pétrole*, Sept 8, 1909; 5 pp.)

Richards, Frank. "Problems of the Russian Oil Industry." (*Eng. and Min. Journ.*, July 10, 1909; 1½ pp.)

Rogers, A. P. "The New Oil Field in Southeastern Utah." (*Eng. and Min. Journ.*, May 15, 1909; 1 p.)

Taff, J. A. and Reed, W. J. "The Madill Oil Pool, Oklahoma." (*Bull.* No. 381-D, U. S. Geol. Surv., 1909; 10 pp.)

Talbot, Frederick A. "New Method of Extracting Oil from Boreholes." (*Eng. and Min. Journ.*, May 15, 1909; 2 pp.)

Thompson, A. Beeby. "The Modern Employment of Liquid Fuels." (*Univ. of Birmingham Eng. and Min. Journ.*, July, 1909; 6½ pp.)

Toroceanu, V. "Les Explorations faites en Roumanie pendant ces Dernières années et la Zone de Poluiori-Beciu-Arbanas." (*Revue du Pétrole*, Aug. 8, 1909; 4½ pp.)

Villarello, J. D. "Some Petroleum-Bearing Regions of Mexico." (*Min. Journ.*, May 15, 1909; ¾ p.)

Villarello, J. D. "Principal Petroleum-Bearing Regions of Mexico." (*Min. World*, July 3, 1909; 3½ pp.)

Weed, R. "Oil Shales in Scotland." (*Iron and Coal Tr. Rev.*, Aug. 6, 1909; 1⅓ pp.)

Wheeler, H. A. "Oil and Gas in the St. Louis District." (*Journ.* Assn. Eng. Soc., April, 1909; 11 pp.)

White, Jay. "The Petroleum Deposits of Colombia." (*Petrol. Rev.*, Nov. 6, 1909; 1¼ pp.)

Washburne, C. W. "Development in the Boulder Oil Field, Colorado." (*Bull.* 381-D, U. S. Geol. Surv., 1909; 2½ pp.)

Washburne, C. W. "The Florence Oil Field, Colorado." (*Bull.* 381-D, U. S. Geol. Surv., 1909; 27½ pp.)

PHOSPHATE ROCK.

By Frederick W. Horton.

The production of phosphate rock in the United States in 1909 was 2,184,399 tons as compared with 2,375,031 in 1908. The decrease may be directly attributed to the depressing effect on the market of the unprecedented large output in 1908. The principal producing States in order of their importance were Florida, Tennessee and South Carolina. A few thousand tons were contributed by Arkansas and Idaho. The accompanying tables give the production, imports, exports and consumption of phosphate rock in the United States for a period of years, and the production of the leading foreign countries.

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES. (*a*)
(In tons of 2240 lb.)

Phosphate.	1906 (*a*)		1907 (*b*)		1908 (*c*)		1909	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida hard rock...	561,370	$3,312,083	589,217	$3,714,767	642,259	$6,262,025	478,820	$3,351,740
Florida land pebble.	603,382	1,810,146	721,028	2,523,598	1,026,392	5,131,960	1,098,964	4,121,115
Florida river pebble.	41,742	116,878	36,729	139,570	5,000	17,500	5,000	15,000
Total, Florida....	1,206,494	$5,239,107	1,346,974	$6,377,935	1,673,651	11,411,485	1,582,784	$7,487,855
S. Car. land rock....	270,000	$990,000	228,354	$890,581	250,000	$1,687,500	197,000	$648,838
S. Car. river rock....	45,000	144,000	37,303	126,830	40,000	240,000	9,500	33,250
Total S. Carolina..	315,000	$1,134,000	265,657	$1,017,411	290,000	$1,927,500	206,500	$682,088
Tennessee..........	520,381	$2,029,486	626,683	$3,008,078	403,180	$1,673,197	388,380	$1,456,425
Other States.......	10,867	61,942	12,145	47,098	8,200	28,700	6,735	23,500
Total, U. S.......	2,052,742	$8,464,535	2,251,459	$10,450,522	2,375,031	$15,040,882	2,184,399	$9,649,868

(*a*) Statistics of 1906 are those of J. M. Lang & Co., Savannah, Ga., with respect to quantity, and are based upon shipments. (*b*) As compiled by *The Mineral Industry*, the tonnage figures for Florida being supplied by J. M. Lang & Co. (*c*) Statistics of J. M. Lang & Co., except for Tennessee and Other States.

STATISTICS OF PHOSPHATES IN THE UNITED STATES. (*a*)
(In tons of 2240 lb.)

Year.	Production	Imports.	Exports. (*b*)	Consumption.	Year.	Production	Imports.	Exports. (*b*)	Consumption.
1900.......	1,527,711	144,006	619,995	1,051,722	1905......	1,933,286	82,072	934,940	1,080,418
1901.......	1,483,723	180,714	729,539	934,898	1906......	2,052,742	46,228	904,214	1,194 756
1902......	1,600,813	145,793	802,086	944,250	1907......	2,251,459	25,896	1,018,212	1,259,143
1903......	1,581,576	153,972	785,259	950,289	1908......	2,375,031	26,734	1,196,175	1,205,590
1904......	1,874,428	166,090	842,484	1,198,034	1909......	2,184,399	11,903	1,020,556	1,175,746

(*a*) Production statistics of 1901 and subsequent years, except 1905-1909, are those of the U. S. Geological Survey and are based on marketed products. (*b*) Neglecting the insignificant re-exports of foreign product.

IMPORTS OF FERTILIZERS INTO THE UNITED STATES.
(In tons of 2240 lb.)

	1906		1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Guano	22,947	$320,565	29,141	$365,257	31,469	$420,724	37,776	$734,636
Crude phosphates	23,281	147,547	25,876	163,944	26,734	175,365	11,903	97,277
All other fertilizers	....	4,231,723	....	4,994,346	....	4,394,434	....	5,673,177

PRODUCTION OF PHOSPHATE ROCK IN THE WORLD.
(In metric tons.)

	1902	1903	1904	1905	1906	1907	1908
Algeria	260,859	301,112	344,969	334,784	333,531	315,000	452,060
Dutch W. Indies	10,530	15,511	22,764	22,940	26,138	(c)	(c)
Belgium	(b)135,850	(b)184,120	(b)202,480	(b)193,305	(b)152,140	181,230	198,030
Canada	776	1,205	832	1,180	(c)	680	1,622
Christmas Island	61,179	70,096	71,757	97,052	90,561	290,000	104,650
France	543,900	475,783	423,521	476,720	469,408	375,000	485,607
Norway	2,295	1,795	1,456	2,522	3,482	1,830	(c)
Ocean and Nauru Islands	....	....	....	....	....	....	301,160
Russia	13,709	14,635	20,282	20,585	13,891	(c)	(c)
Spain	1,150	1,124	3,305	1,370	1,300	3,078	4,483
Sweden	3,895	3,219	2,929	(c)	(c)	5,317	(c)
Tunis	263,482	332,888	455,789	559,645	796,000	1,069,000	1,300,500
United States	1,514,159	1,606,881	1,904,419	2,135,449	2,085,586	2,251,459	2,413,150

(b) Metric tons of phosphate of lime; in addition there were 315,200 cu.m. of phosphatic chalk in 1902, 350,250 cu.m. in 1903, 311,640 cu.m. in 1904, 80,380 cu.m. in 1905 and 119,450 cu.m. in 1906. (c) Statistics not available.

Prices at the beginning of the year were more or less nominal, but towards the close considerable strength was noted in the market, and the following schedule was quite closely adhered to: Florida land pebble, f.o.b. Port Tampa, Fla., $3.75@4 per ton; high-grade rock, f.o.b. Florida or Georgia ports, $7@7.50 per ton; South Carolina undried, f.o.b. Ashley river, $5.50@5.75 per ton; Tennessee A and No. 1 f.o.b. Mount Pleasant, $3@3.50 per ton; 75-per cent. brown rock, $4.75@5, and 68- to 72-per cent. rock, $4.25@4.50 per ton.

Phosphate Land Withdrawals.—Phosphate land withdrawals, in force March 4, 1909, covered all vacant public lands in an area comprising 4,493,551 acres in Wyoming, Utah and Idaho. During the year 2,389,141 acres were restored to entry, for field work showed that they contained no phosphate. Additional withdrawals, including 399,693 acres were made, and the form of withdrawal was changed so as to cover entered as well as vacant lands. All unpatented lands in an area of 2,504,103 acres are now affected by phosphate withdrawals. Portions of the lands thus reserved were examined in 1909 by geologists of the United States Geological Survey, whose reports have been published in Bulletin 430-H. The deposits are described and mapped in detail, and estimates are given of the available phosphate in the areas considered. The areas examined contain more than 267,000,000 tons of high-grade rock, and as the deposits probably extend far beyond the areas considered, this Western phosphate field is perhaps the largest in the world. There is little prospect that the Western phosphates will be extensively mined in the near future, owing to the great distances to present markets. However, with the growing demand in the West for fertilizers and the gradual depletion of the more accessible deposits, these Western fields will undoubtedly come more and more into prominence. At present all the phosphate mined in the Idaho-Wyoming-Utah area is sent to California for fertilizer manufacture. The consumption is steadily growing, having increased from 10,000 to 35,000 tons during the last four years.

Phosphate in the United States.

Alabama.—In 1909 about 15 square miles of rich phosphate rock were discovered on Blue Water creek at Arkdell, Lauderdale county. Options on the ground were secured by the Luminolier and Manufacturing Company of Birmingham and development work will probably be commenced soon. Preliminary examinations of the territory indicate that the rock exists in great quantities.

Arkansas.—A few thousand tons of rock are annually mined by the Arkansas Fertilizer Company from deposits on Lafferty creek in Independence county. The phosphate bed is from 2 to 6 ft. thick, and while some rock contains as high as 73 per cent. tricalcic phosphate, the bulk of the deposit is of low grade running from 30 to 50 per cent. At present the material is shipped to Little Rock, where it is made into acid phosphate.

Florida.—The production of phosphate rock in Florida in 1909 was 1,582,784 tons, as compared with 1,673,651 tons in 1908. Of this amount 478,820 tons were hard rock, 1,098,964 tons were land pebble and 5000 tons were river pebble. The decrease in the total production was due to the falling off in the output of hard rock, of which 642,259 tons were produced in 1908. Shipments of land pebble showed a gain of 72,572 tons.

Prices at the beginning of the year continued to reflect the situation created by the large production in 1908, and sales of high-grade rock were made at $5 per ton and of land pebble at $2.60 per ton, f.o.b. mines. During the year, however, a large portion of the phosphate shipped was delivered against contracts made when prices were good. At the beginning of the year nearly all of the plants in the hard-rock district were idle on account of the excessive rains, and by reason of the low prices there was a further voluntary curtailment of production. Very little hard rock was sold as compared with former years and not a great deal was contracted for delivery during 1910. The miners are convinced that the rock is worth more to them in the ground than sold at the low figures offered.

During the year the Prairie Pebble Phosphate Company was purchased by the International Agricultural Corporation for a consideration of $8,000,000. The Prairie Pebble company was the largest producer of phosphate rock in Florida and had a capacity of more than 500,000 tons annually, producing approximately half of the pebble phosphate output of the State from five mines at Mulberry, Phosphoria and Kingsford. The following article gives a detailed account of operations in Florida during 1909:

(By C. G. Memminger.)—Almost unprecedented depression prevailed during 1909 in the Florida phosphate industry. There appeared to be an absolute lack of demand for phosphate, in both domestic and foreign markets. The prices during the first half of the year continued to decline, and sales of Florida high-grade hard rock were reported to have been made at $5, and of Florida land pebble at $2.60 per ton, f.o.b. mines. The average price for the former in 1908 was $7.66 per ton and the latter $3.58 per ton.

These conditions were largely due to the fact that during the period of high prices about three years ago, heavy contracts covering long periods were entered into by the consumers, who, fearing a shortage, covered their requirements fully under these contracts. As a consequence the offerings for new business were extremely restricted, and at the same time, there being no co-operation on the part of the miners in disposing of their product, the result was a general struggle to secure what little new business there was. During the second half of the year these conditions were somewhat mitigated and showed steady improvement during the last quarter. Indications are that 1910 will bring an active demand, with a marked increase in prices.

The policy of the producers in the hard-rock district was an extremely wise one, they having restricted their output to meet only current contracts. Stocks were reduced, fully 60 per cent. of the mines closed down, and it is evidently the intention of the producers to keep their mines closed until the market improves and rock can be disposed of at profitable figures. This action will unquestionably bring about the desired results in a short period. There were no new mines opened in the hard-rock district, and the producers fully realize the necessity of conserving their deposits, knowing that the quantity of high-grade, Florida hard rock is by no means unlimited.

In the hard-rock district transportation facilities were largely increased by extension of the Seabord Air Line tracks into various portions of the field where hitherto the Atlantic Coast Line exclusively handled the product from the mines. The rivalry between these two railroads will be of great benefit to the producer, giving betterment of service and added facilities.

There were two marked changes in the methods of handling hard rock, which were successfully inaugurated by the Cummer Phosphate Company and the Dutton Phosphate Company. These two companies, instead of following the former method of drying the rock at their mines by a crude method previous to making shipment, adopted plans whereby the phosphate, after being washed, is transported to terminals at Jacksonville. Here the rock is dried by rotary driers of an improved type, and stored in bins on the docks. This method proved extremely successful and economical, especially in the case of the Cummer Phosphate Company, where fuel was obtained as a by-product from its saw mills. The rock is stored in quantities at the terminals, which gives the added advantage of permitting prompt loading. There has always been a prejudice in connection with the use of the rotary driers in the handling of hard rock, but the method adopted by these companies fully demonstrated that driers of this type can be successfully and economically employed. The port of Jacksonville, owing to the establishment of these drying and storage plants, became one of the chief export terminals in Florida.

In the pebble-phosphate section the miners, through lack of co-operation, did not adopt the plan pursued by the hard-rock people in restricting their output, and practically all of the mines were run to their maximum capacity. The market for pebble phosphate, however, fortunately increased so largely that the results were not as disastrous as might have been expected, though a heavy restriction in the output in this district would have been extremely advantageous under the circumstances.

There were no new plants constructed during 1909, the only new plant going into operation being that of the Coronet Phosphate Company, construction on which was begun about June, 1908. The Coronet and Medulla phosphate companies are producers of practically a new grade of pebble, which is sold on an absolute minimum guarantee of 74 per cent. phosphate of lime. Cargo shipments from both of these plants showed analyses running from 76 to 77 per cent. tricalcic phosphate, which is practically in the same class as the Florida, high-grade, hard-rock phosphate. The demand for this class of phosphate is practically restricted to foreign consumption.

A feature of interest in 1909 was the completion of the Seaboard export terminals, at Tampa. These terminals are designed along the most approved engineering lines, and excellent facilities are afforded for the prompt handling and despatch of phosphate. The elevators are constructed with storage bins of 3000 tons capacity, so that a cargo for an ordinary vessel can be held ready for its arrival. The Seaboard Air Line also had constructed about 200 steel, hopper-bottom cars, of 100,000 tons capacity, especially designed for handling pebble phosphate, the cars being arranged so that the phosphate may be directly loaded into the top. The Seaboard is also extending its lines further into the pebble district, and will unquestionably become an active competitor with the Atlantic Coast Line in the handling of this class of phosphate.

Sale was reported of the holdings of the Prairie Pebble Phosphate Company, the largest producer in the pebble district, to the recently organized International Agricultural Corporation, which is the reported owner of one of the largest potash mines in Germany, and which also, it is claimed, controls the sulphuric-acid output of the Tennessee Copper Company at Copperhill, Tennessee.

There were no marked changes in the general method for the mining and handling of pebble phosphate, except that the more modern and up-to-date plants introduced greater refinement in the preparation, and also installed the most approved and economical types of prime movers. In both the hard-rock and pebble districts every effort was made to lower production cost, but owing to the constantly increasing depth of overburden to be handled, the exhaustion of the most economically handled and richest deposits, higher fuel costs and increased distances of transportation to central plants, the cost of production must of necessity constantly increase.

(By E. H. Sellards.)—The hard-rock phosphate now being mined occurs along the Gulf side of the Florida peninsula from Suwannee and Columbia counties on the north, to Citrus and Hernando counties on the south. The hard-rock deposits lie in pockets of irregular occurrence and extent, and usually rest upon limestones of Vicksburg, lower Oligocene, age. The land-pebble deposits are of Pliocene age and are less irregular in their manner of occurrence than are the rock phosphates. The land-pebble region, at present productive, lies in Polk and Hillsboro counties, to the south of the hard-rock region. River pebble has been obtained chiefly from Peace river and its tributaries.

The production of river pebble increased gradually from the beginning of the industry in 1888 to 1893 when the maximum production of 122,820 tons was reached. From the year 1893 to the present time there has been, with some fluctuations, a decrease in the output of river pebble, the total for 1909 being about 5000 tons. River-pebble mining near Arcadia in De Soto county, which has long been the center of this industry, was discontinued at the close of 1908. Practically all of the hard-rock phosphate produced in Florida is exported, the home consumption of this grade being insignificant.

Georgia.—A deposit of phosphate rock of good grade was discovered in 1909, about three miles northeast of Cordele. The deposit covers an area of about 200 acres, but the depth of the bed has not been ascertained.

Idaho. (By F. C. Moore.)—The San Francisco Chemical Company of Montpelier, Bear Lake county, owns the only productive deposit of phosphate rock within the State. From this property 735 tons of rock were shipped in 1909, averaging from 60 to 70 per cent. calcium phosphate. The company contemplates extensive operations in the future. The rock occurs in flat-dipping beds in a sedimentary formation identified as belonging to the Upper Carboniferous series. The veins range from a few inches to 10 ft. in thickness.

Kentucky.—In July, 1909, the Central Kentucky Phosphate Company was incorporated for the purpose of developing the phosphate beds which have been discovered in the vicinity of Mt. Vernon, Woodford county. Active prospecting was carried on in this vicinity, and some extremely rich rock is said to have been found. These strikes caused considerable excitement in Woodford county, which is extending to Fayette county, where the indications are said to be almost as good.

South Carolina.—The production of land rock in South Carolina in 1909 was 197,000 tons, as compared with 250,000 tons in 1908. There was also a large decrease in the output of river rock, which amounted to only 9500 tons, as compared with 40,000 tons in the previous year. Carolina land and river rock contain about 55 to 58 per cent. tricalcic phosphate respectively. In 1909, the principal operators of land-rock deposits were the Charleston Mining and Manufacturing Company, Charleston, and P. B. and R. S. Bradley, of Boston. The largest miner of river rock was the Central Phosphate Company, of Beaufort. The phosphate deposits of South Carolina are practically exhausted, reserves of high-grade rock being calculated at less than 3,000,000 tons. The value of rock at the mines was from \$3.25@3.50 per ton. Quotations on undried rock, per long ton, f.o.b. Ashley river, averaged from \$5.50@5.75, but for large lots slight concessions were made from these figures.

Tennessee.—Total shipments of phosphate rock from Tennessee in 1909, including both export and domestic grades, were 388,380 tons, as compared with 403,180 tons in 1908. The following article gives a detailed account of the industry in the State during 1909:

(By H. D. Ruhm.)—In 1909 production and shipments continued to be somewhat below the normal of the Tennessee field, although quite a stimulus was felt after Aug. 1, and 1910 bids fair to again show a normal production. During the stagnation period the manufacturers of fertilizers took advantage of the opportunity to thoroughly fortify themselves with supplies of rock in the ground, so that for a long time to come, the chances are that values as shown by sale prices, will consist merely of the nominal figures at which the phosphate-mining departments charge up the rock to the fertilizing departments.

The Independent Fertilizer Company, organized in 1908 by T. C. Meadows with the aid of J. P. Morgan & Co., was finally dissolved by the manufacturers who were in it, at a time when Mr. Meadows was on the other side of the ocean. On his return he organized the International Agricultural Corporation, which was composed of the Buffalo Fertilizer Company and its affiliated concerns, the National Fertilizer Company of Nashville, Tenn., the Tennessee Valley Fertilizer Company of Florence, Ala., the Germo-Fert Company of Atlanta, Ga. and Montgomery, Ala., the Blue Grass Phosphate Company, the Jackson Phosphate Company, Middle Tennessee Phosphate Company, Brown Rock Phosphate Company, Maury Phosphate Company, Little Bigby Phosphate Company, T. C. Meadows & Co., Richland Phosphate Company, France & Co., Ruhm & Gregory, Sterling Phosphate Company, all of Mt. Pleasant, the American Phosphate Company at Wales, Tenn., and the Kaliwerke Sollstedt, of Sollstedt, Germany.

With their already strong position augmented by the recent purchase of the Prairie Pebble Phosphate Company's holdings in Florida, and with the expected increase in the sulphuric acid production at Ducktown, Tenn., which it has the contract to consume, the International Agricultural Corporation stands without a rival in the world today. Its possessions of raw material for the manufacture of fertilizer and facilities for its manufacture and distribution are ample and ideally located, and the organization is successfully at work.

The American Agricultural Chemical Company continued to operate its plants at Wales and Centerville, but with a reduced output. The Virginia-Carolina Chemical Company greatly increased the capacity and efficiency of its washing and drying plant at its Arrow mine, and is now transporting the waste product from the Howard and Ridley mines to Arrow for washing and drying. Its blue-rock mines at Mayfield were operated regularly and it greatly increased the drying capacity there. The Independent Phosphate Company operated at Satterfield and Solita, and is rapidly pushing ahead the development of its blue-rock mines at Leatherwood. The latter mine and Mayfield mines of the Virginia-Carolina Company are the best blue-rock mines in the field.

The Middle Tennessee Railroad Company was nearly completed from Nashville to the Leatherwood mines and a contract was signed for its extension to Mt. Pleasant during 1910. This will give the phosphate field of Tennessee the much-needed competition in railroad facilities and should go far toward relieving car-shortage troubles.

In the Centerville district only the Volunteer State Phosphate Company and the Meridian Fertilizer Factory ran to any extent during 1909. The Virginia-Carolina operations at the Fogg mines are reported to have about worked out the Duck River Phosphate Company's holdings. At the Bear Creek mines, owned by the Tennessee Chemical Company, recently absorbed by Armour & Co., considerable activity was manifested and plans are now in preparation for installing an up-to-date washer and dryer. The Federal Chemical Company at Century and Ridley operated continuously, having the largest and best equipped washing and drying plants in the field.

The Independent Phosphate Company had one washing plant; the International Phosphate Company, one; Federal Chemical Company. two; Ruhm Phosphate Mining Company, one; International Agricultural Corporation, four; in operation in the Maury county field.

The prices of rock for the few outside sales that were made, were in sympathy with general conditions at $3@3.40 for 72-per cent. rock with $6\frac{1}{2}$ per cent. iron and aluminum, and $3.50@4 for 75-per cent. rock with $5\frac{1}{2}$ per cent. iron and aluminum. Blue rock was quoted around $2.65@3.25 for 60- to 65-per cent. rock with 3 per cent. iron and aluminum and export grade containing 78 per cent. tricalcic phosphate and 4 per cent. iron and aluminum, at $4.50@5. The ground-rock business continued to increase and the following firms are now engaged in grinding: Ruhm Phosphate Mining Company, Farmers' Ground Rock Phosphate Company, Mt. Pleasant Fertilizer Company, International Agricultural Corporation, Central Phosphate Company, and Cooper & Jackson.

The central freight association having recently decided to give the same rate on ground phosphate in bulk that is given on lump rock, the use of ground rock directly, without acidulation, will greatly increase, the discrimination in rates heretofore having prevented much of it from being used. The new process of washing and saving all the phosphate granules about trebled the supposed available tonnage of brown rock of 72 per cent. or higher, and many deposits supposed to have been worked out are now found to contain more available tonnage than was recovered at the first superficial mining, when only lump rock was saved.

Phosphate Mining in Foreign Countries.

Algeria.—The production of phosphate rock in Algeria in 1908 amounted to 452,060 metric tons, the country ranking fourth in the list of the world's producers. In 1909 exports from Bone derived from the mines at Kouif, Kissa and Dyr, amounted to 283,761 tons, and from Bougie, 67,730 tons, a total of 351,491 tons. There are many phosphate deposits in Algeria which are merely of local importance, but those found near Ain Sha are of considerable extent and it is calculated that at least 42,000,000 to 49,000,000 cu.ft. of workable phosphates are in sight. In the department of Constantine the phosphate deposits are mined on a large scale. These occurrences may be divided topographically into four groups; namely, (1) Bordsh, Bu, Arrerissh and Setif; (2) El Gerrah-Ain Beda; (3) Suk Arras and Guelma; and (4) Temessa. Northeast of the last-named locality only one bed, about 10 ft. thick, has been worked. The phosphate averages between 55 and 69 per cent. tricalcic phosphate, reaching a maximum of 73 per cent. in the richest portions.

Belgium.—The mining of phosphate in Belgium is confined to the provinces of Liége and Hainault. The production in 1908 amounted to 198,030 metric tons. In the Hesbaye district of Liége the workable phosphate bed lies at a depth of from 50 to 80 ft., and usually ranges in thickness from 16 to 20 in., and contains from 22 to 33 per cent. of phosphoric acid. The usual method of work is to sink rows of small circular shafts without tubbing. The shafts are generally 65½ ft. apart, and the distance between each row is 100 ft. When the phosphate bed is reached the several shafts in each row are joined by a tunnel, and generally from one end of each row a crosscut is driven to join the next tunnel. As the material is soft it is mined with picks, and after a preliminary rough sorting, shoveled into skips and hoisted. Above ground, women subject the material to a second, more careful sorting. There is no trouble with water in the mines, and scarcely any timbering is used. It takes about three months to work out an area 328x20 ft. Wages are paid on the piecework system, averaging for men 4s. 2d. per day, and for women sorters 1s. 5½d. A ton of phosphate, containing, as it comes from the mine, 20 per cent. moisture, costs from 1s. 1d. to 1s. 2d. per ton delivered at the works, not including interest on capital and amortization. The better grade of phosphate after drying and cleaning may contain as much as 60 per cent. of tricalcic phosphate and finds a ready sale. The lower grade, after careful grinding and coloring with a green aniline dye, is largely sold in Brittany. The Bretons formerly obtained all their phosphate from the Ardennes, and as this had a green coloration, they reject any phosphate that is not green as being a poor fertilizer.

The phosphate of Hainault, which furnishes the greater part of the Belgian output, is chiefly obtained in the neighborhood of Mons, where it occurs in two forms, (1) the so-called rich phosphate, and (2) the phosphatic chalk. The phosphate beds occur in an incompletely closed basin, the deepest point of which lies directly beneath the town of Mons. The beds thin out toward the rim of the basin but thicken immensely toward the center, although at the same time the proportion of phosphate contained diminishes considerably. Three horizons are discernible in the phosphate beds; the lowest containing many bands of flint and little phosphatic chalk; the middle, without flint and much richer in phosphate (up to 15 per cent.); and the upper with much flint, but also by far the richest in phosphate. This latter constitutes the workable phosphatic chalk and contains a maximum of 40 per cent. tricalcic phosphate. The material has to be submitted to a process of enrichment in order to make it marketable.

The general method of working the phosphate at Mons is by surface stripping, followed by quarrying. A large phosphate working at St. Symphorien has a daily output of 600 to 650 metric tons. The quarry is lighted by electricity, and operations are carried on at night. The cost of mining at this quarry is from 10s. to 11s. 8d. per ton. West of Mons the tendency is toward underground workings. Of such, the Malogne Company's mines, near Cuesmes, are an example. At these mines pillars, varying in thickness from 13 to 20 ft., in inverse ratio to the solidity of the roof, are left in the workings, and there is practically no timbering. The heavy damages payable to land owners in case of disturbance of the surface forbid any attempt to extract the pillars, and thus much phosphate goes to waste.

Christmas Island.—Shipments of phosphate rock from Christmas Island in 1909 were 105,000 tons, as compared with 103,000 tons in 1908. Of this amount 85,000 tons went to European markets and the remainder to Australia and Japan. The island is not much over a mile long and a quarter of a mile in width, but a considerable proportion of its area is covered with deposits of marketable rock. The phosphate-bearing formation consists of a shell limestone, which has been converted into rock phosphate, overlain with cream-colored limestones, and often ferruginous fine-grained sand, on top of which is an irregular deposit of phosphatic travertine limestone in layers or nodules.

Considering the shell limestone, that at the north of the island is too low in phosphoric acid to be of commercial value; but in the central area there is over 15,000 cu.yd. of material containing 13½ per cent. of phosphoric acid. In the southern portion of the island it is estimated that there are about 36,000 cu.yd. of rock averaging 11.5 per cent. phosphoric acid and worth about £1 9s. per ton. On the western shore an outcrop of phosphate rock shows about 1000 cu.yd., with an average phosphoric acid content of 23.6 per cent. and worth about £3 per ton. The value of the phosphatic travertine varies considerably, the best being found in brown resinous-looking veins, or coatings of almost pure tricalcic phosphate. Some of the travertine appears as a white vitreous limestone, containing scarcely a trace of phosphoric acid. About 153,600 sq.yd. of ground are covered with phosphatic travertine to an average depth of two feet.

France.—The production of phosphate rock in France in 1908 was 485,607 metric tons, valued at 9,743,185 fr., or 20.06 fr. per ton. The domestic output is insufficient to supply the demand, and large quantities of raw phosphate are imported and transformed into superphosphate at Nantes. Imports in 1908 were 767,424 metric tons, of which 79,341 tons came from Algeria, and 442,355 tons from Tunis. Exports in the same year were 71,509 metric tons.

Germany.—Phosphate, which is free of duty when imported into Germany, is ground and converted into superphosphate at numerous factories in that country. Imports in 1909 were 663,400 metric tons, as compared with 736,127 metric tons in 1908. Over one-half of this amount came from the United States, which furnished 335,475 tons. Supplies from other countries were as follows: Belgium, 79,995; France, 15,996; Algeria, 128,362; Tunis, 27,739; British Australasia, 60,783; German Australasia, 10,993 metric tons. The German importers demand 77-per cent. rock, with a tolerance of 1 per cent., but they have been purchasing American shipments containing as low as 73 per cent. of tricalcic phosphate. Hamburg and the adjoining city of Harburg import chiefly Florida rock phosphate and the Algerian product. Considerable quantities are also received from Tunis. Of the shipments of phosphate arriving in Hamburg, very small quantities are re-exported. It would not be remunerative for the German superphosphate factories to seek a market outside of Germany, in north Europe, or elsewhere, as well-organized competing factories may be found wherever there is any considerable demand for this fertilizer. While the freight rate per ton of phosphate from Algerian ports is $1.70, and from Tunisian ports $1.82, shipments from America are generally subject to a rate approximating $2.43 per ton.

Italy.—In 1909 Italian imports of phosphate from the United States were 146,669 metric tons, and from Africa, 71,780 metric tons. As compared with imports in 1908 this is a decrease of 33,378 metric tons for American phosphates, and 32,621 tons in the case of African rock. The imports from the United States in 1909 consisted of 16,974 tons of Tennessee rock, 128,010 of Florida land pebble, and 1685 tons of Florida hard rock. The imports of African phosphate were composed of 218,315 tons from Gafsa, 175,830 tons from Kalaa-Djerda, 8790 tons from Kalaat-es-Senan, 11,780 tons from Constantine, 2770 tons from Tebessa, and 3695 tons from Salsalla.

Mexico.—In northern Coahuila is an extensive formation of phosphatic limestone. Recent investigations show that it contains from 15 to 20 per cent. phosphoric acid. The deposit is off the railroad and no attempt has been made to exploit it.

The Netherlands.—In the Netherlands there are several large fertilizer works, manufacturing for both the home market and export, which are large users of crude phosphate. Raw phosphate from the southern ports of United States form an important cargo into Rotterdam, and while large quantities of the mineral are reshipped up the Rhine into Germany, the Dutch factories probably consume from 60,000 to 70,000 tons per year. Crude phosphates are on the Dutch free list and pay no import duty. The products of Christmas Island, Panope, and other sources of supply in the Pacific seldom find their way into this market, but the Florida rock meets with serious competition from the Tunisian and Algerian product. These African phosphates seldom run better than 55 to 60 per cent. tricalcic phosphate, while the best grades from Florida contain over 75 per cent. However, the item of cheap labor at the mines, and shorter ocean transportation is in favor of the Dutch buyer when purchasing from Africa, as against Florida.

New Zealand.—A government bonus was offered in 1909 for the discovery of deposits of mineral phosphate in New Zealand, and as a result over 500 samples of supposed phosphate were submitted to the Department of Agriculture for examination. Most of these proved valueless, only three samples of true phosphate being received. Two of these were obtained near Whangarei, one containing 87 per cent. of tricalcic phosphate, and the other showing 78 per cent. A specimen from Fort Robinson contained 37 per cent. of phosphate of calcium, and a boulder from Kamo, Whangarei, contained 62 per cent. These specimens indicate the possibility of there being workable deposits of the mineral in North Island.

Oceanica.—In 1909 shipments of phosphate rock from Ocean and Nauru Islands, by the Pacific Phosphate Company, of London, were

202,000 tons, as compared with 296,400 tons in 1908. Of this amount 137,000 tons were shipped to Australia and Japan, and 65,000 tons went to European markets. It is of interest to note that, notwithstanding the severe slump in prices, the Pacific company, in 1908, declared a dividend of 250 per cent., payable 50 per cent. in cash and the balance in stock.

France has two phosphate companies in Oceanica. The older is the Compagnie Française des Phosphates de l'Océanie, floated in 1908 with a capital of 6,000,000 fr. The more recently organized Compagnie Française des Phosphates du Pacifique has a capital of 600,000 fr., and for the present aims only at prospecting certain Pacific islands. Upon the discovery of large deposits of high-grade phosphate on the island of Makatea, both these companies took possession and suits are now pending before the tribunal of Papeete to determine the rights of each. Since the discovery of phosphate on Makatea and two other islands of the Tuamotu group, deposits of good phosphate have been found on Henderson (Elizabeth) Island, a British possession lying a little to the east of the Gambier Islands. Concessions have been granted to work any deposits found on this and two other uninhabited islands, Ducie and Oeno, in that vicinity. The Deutsche Südsee Phosphat Aktiengesellschaft obtained the concession of Anguar Islands from the German government in 1908. This company is capitalized at 5,625,000 marks and will soon commence development work.

Russia.—The principal phosphate deposits of Russia are situated in the provinces of Kostrom, Podolia, Bessarabia and Kursh. The Podolia and Bessarabia deposits, in the basin of Dniestre, are the most important, and have been worked for many decades. The Podolian phosphates occur as nodules, averaging about 3 lb. in weight and containing from 70 to 80 per cent. of tricalcic phosphate. From 20,000 to 30,000 tons of this material are mined annually and exported, mostly to Bohemia. Part of the rock is shipped crude and part is made into phosphate meal. The cost of mining is about 6s. per ton, and until recently it has cost 12s. per ton to deliver the material at the railroad at Derazhneya from whence it is shipped to Odessa. A railroad is now being built to the phosphate deposits and will greatly cheapen the cost of delivery. Mining is carried on in the most primitive style, the rock being extracted from galleries about 21 ft. wide and 21 ft. high. The galleries are run for lengths of 210 ft, or more, and large pillars left between them.

Respecting the size of the deposits, E. de Hauptick, of the Imperial Russian engineers, estimates that the area occupied by the phosphate formation in Podolia is about 1400 square miles, and in Bessarabia about

160 square miles, a total of 1560 square miles. Assuming that each mile contains 51,800 tons of phosphate rock, which is about the present yield, the reserves of the whole area are 80,808,000 tons.

In the province of Kostrum two beds of phosphate rock, containing 15.3 per cent. of calcium phosphate, occur in the Kineschem district. This material is made into phosphate meal. Similar deposits are met with in the provinces of Yaroslaz, Moscow, and Smolensk. In the Kursh district there are two beds of phosphatic sandstone inclosing a large number of bones, shells, etc. Up to the present time these Kursh phosphates have not been used as fertilizers.

Seychelles Islands.—Many samples of phosphate rock from the Seychelles Islands have been obtained which assay from 50 to 80 per cent. tricalcic phosphate. The Seychelles deposits appear to have been formed by the alteration of coral limestone by the infiltration of phosphoric acid from overlying deposits of guano. The commercial exploitation of the deposits is now being undertaken.

Syria.—A proposal for a concession of phosphate lands in Syria is now being considered by the Turkish Chamber of Deputies. The phosphate deposits must, in order to be exploited, be connected by a branch line 25 miles long with Annam, on the Hedjaz railroad, while at the same time a harbor must be constructed at Caiffa. The cost of this work is estimated at $2,500,000, which the concessionaires will undertake to advance to the government at 3½ per cent. interest. The loan is payable in 40 years, which is the duration of the concession. The concession holders will pay the government $2.20 per ton of rock transported and will undertake to ship annually at least 100,000 tons, at the same time supplying the native farmers with all the superphosphate they require at cost price. On the expiration of the concession the deposit, the railway line and the harbor will become the property of the State.

Tripoli.—A party of French engineers are said to have discovered phosphate deposits in Tripoli, but these deposits cannot be worked profitably without building a railroad to the coast.

Tunis.—The production of phosphate rock in Tunis in 1909 was 1,280,300 metric tons, as compared with 1,300,500 metric tons in 1908. Of this amount Gafsa supplied 965,000 tons. Kalaa-Djerda, 191,900 tons and Kalaat-es-Senam, 123,400 tons. During the year shipments to Europe from Sfax were 890,181 tons and from Tunis 334,442 tons, a total of 1,224,603 tons. In 1908 exports to Europe were 1,261,211 tons. A French company, the Société des Phosphates de Gafsa controls the larger part of the phosphate deposits of Tunis and is probably the largest miner and seller of phosphate in the world, shipping over 1,000,000 tons annually. This company owns enormous deposits in the south of Tunis at Metlaoui, Redeyef and Ain Moulares. The deposits of Metlaoui and Redeyef alone are estimated to contain 17,000,000 tons of high-grade rock. A railroad system owned by the company connects the mines at Metlaoui and Redeyef with Sfax on the coast. In 1909 construction work was commenced on a branch line to connect Souatir, the terminus of the railroad built from Susse by the Bone-Guelma Railway Company, with the Metlaoui-Redeyef railroad. The Gafsa Company also obtained a lease of the proposed Sfax-Bou-Thadi line, which is to be built by the Tunisian government.

The new plant of the company for shipping ores at Sfax was completed in 1908. The sheds under which the phosphate rock is stored covers an area of 25,000 sq.m. Rock is handled by an extensive system of 24-in. Robins belt conveyers, having a total length of 906 m. Three 24-in. conveyers, are able to load 200 tons of rock per hour each. The whole plant at Sfax is driven from a central power plant fitted with two 150-h.p. gas engines. The completion of the Sfax-Sousse railroad will enable the company to utilize the harbor at Sousse for shipping its phosphate rock. The Sousse plant will also be fitted with an extensive system of conveyers. The opening of the tramway from Sousse to Ain Moulares and the adding of a second track from Tunis to Kalaa-Djerda will assist greatly to develop the industry.

Bibliography.

Among the many papers on phosphate rock that appeared in the technical press during 1909, the following are noted:

Anonymous. "Phosphate Deposits of Algeria and Tunis." (*Am. Fertilizer*, Apr., 1909; 1¼ pp.)

Aguillon, L. "L'Industrie des Phosphates Mineraux." (*Ann. des Mines*, Vol. XV, No. 5, 1909; 33½ pp.)

Dumas, William C. "A Study of the Methods for the Determination of Iron and Alumina in Phosphate Rock." (*Chem. Eng.*, April, 1909; 6½ pp.)

Hastings, W. D. "Tennessee's Phosphate Field." (*Mfrs. Rec.*, Jan. 7, 1909; 1½ pp.)

James, Carlton C. "Moisture Discrepancies in Phosphate Rock of the Pacific." (*Journ. Ind. and Eng. Chem.*, Sept., 1909; 2 pp.)

Mingaye, J. C. H. "Power Plant of the Coronet Phosphate Company, near Plant City, Florida." (*Eng. Rec.*, Oct. 23, 1909; 3⅓ pp.)

Negre, G. "Contributions a l'Etude de la Formation des Phosphorites du Midi de la France." (*Bull.* de la Soc. Geol. de France, May, 1909; 16 pp.)

Ross, O. C. "Phosphate Mining." (*Industrial Progress*, Oct., 1909; 9 pp.)

Stone, C. A. "Mining and Milling Florida Phosphates." (*Eng. and Min. Journ.*, Mar. 6, 1909; 2⅔ pp.)

Van Horn, Frank B. "Phosphate Deposits of United States." (*Min. and Sci. Press*, July 17, 1909, 2½ pp.)

PLATINUM.

By Frederick W. Horton.

The production of platinum in the United States in 1909 may be estimated at 750 oz. Most of this was obtained through the Mint, where a considerable quantity is recovered every year as a by-product in the refining of gold bullion and dust, mainly from the placer deposits of California and Oregon. It is impossible to report exact figures of production, as no record is kept by the Mint of the different sources from which platinum is derived, and by far the greater part recovered in 1909 was from the refining of dental scrap. The amount of crude platinum of domestic origin purchased by refiners during the year was probably not in excess of 150 oz. Of this quantity the largest part came from the dredging fields at Oroville and Folsom, Cal. Placer operations in Coos, Jackson, Curry and Josephine counties, Ore., and in Del Norte, Trinity, Siskiyou, Humboldt and Butte counties, Cal., also resulted in the production of a few ounces. The beach sands on the Pacific coast nearly all carry platinum, but little or none was obtained from this source in 1909. A small quantity of platinum was recovered from the platiniferous nickel-copper mattes from the Sudbury district, Ontario, which are shipped to the United States to be refined.

The business of platinum refining in the United States is of considerable importance, and a great deal of foreign crude platinum is refined here, while a large amount of domestic scrap is refined or remelted. With the exception of a few concerns which refine scrap in a small way, the refiners of platinum in the United States are as follows:

Baker & Co., Inc., Newark, N. J.
Croselmire & Ackor, Newark, N. J.
S. S. White Dental Mfg. Co., Prince's Bay, N. Y.
J. Bishop & Co., Malvern, Penn.
American Platinum Works, Newark, N. J.
Roessler & Hasslacher Chemical Company, Perth Amboy, N. J.

The consumption of platinum has vastly increased in the last three years and is now much greater than the production. The refiners are buying scrap from all possible sources so as to remelt it and use it for the current demand. It is estimated that 40 per cent. of the platinum sold in 1909 by refiners was remelted scrap.

Imports of unmanufactured platinum into the United States in 1909 were 118,851 oz., valued at $2,557,574, as compared with 50,768 oz., valued at $1,096,615, in 1908. A large part of the imports was crude Russian metal, usually received here from Paris, where the control of the Russian industry rests. During the latter part of the year there was a considerable increase in the receipts from Colombia.

STATISTICS OF PLATINUM IN THE UNITED STATES.

Year.	Production. (a)		Imports.			Consumption.
			Unmanufactured.		Manufactured	
	Troy Oz.	*Value.*	*Troy Oz.*	*Value.*	*Value.*	*Value.*
1896	163	$944	83,080	$926,678	$106,338	$1,033,960
1897	150	900	83,080	960,299	43,921	1,005,120
1898	225	3,375	101,018	1,178,142	52,283	1,233,800
1899	300	1,800	187,778	1,462,157	55,753	1,539,710
1900	400	2,500	118,919	1,728,777	36,714	1,767,991
1901	1,408	27,526	85,438	1,673,713	24,482	1,725,721
1902	94	1,814	105,450	1,950,362	37,618	1,989,794
1903	110	2,080	114,521	1,921,772	135,889	2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,920,478
1905	318	5,320	104,196	1,985,107	188,156	2,176,263
1906	1,439	45,189	137,556	3,601,021	187,639	3,797,460
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,244,984
1909	750	18,653	118,851	2,557,574	410,997	2,987,224

(a) Statistics of the U. S. Geological Survey, except for 1909.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK.
(In dollars per troy ounce.)

	1906	1907	1908	1909
January	20.50	38.00	25.50	24.10
February	25.00	38.00	25.50	24.00
March	25.00	37.00	25.50	23.75
April	25.00	32.50	23.50	23.50
May	25.00	29.50	22.50	23.25
June	25.40	26.20	23.50	22.75
July	26.00	26.75	20.00	22.43
August	26.00	28.13	18.75	22.65
September	32.10	28.70	20.00	25.31
October	33.00	27.13	21.50	27.75
November	35.50	26.31	24.00	29.50
December	38.00	26.00	24.00	29.50
Year	28.04	28.18	22.85	24.87

Market.—The year opened with a light trade, dealers asking $23.50@ 24.50 per oz. for refined metal, and this condition, with an unchanged quotation, held until the middle of March. A slight drop brought the current price down a little and $23@24 per oz. was quoted until the middle of May. A reduction to $23@23.50 was reported early in June, and 50c. more was dropped in July, the price being $22.50@23, which held for a month. In August the market was disturbed by some holders of small stocks, who found it necessary to realize, and refined platinum could be had at $21@22.50 per oz., the higher price being that asked by the large refiners. About the end of August demand began to improve; sales were larger and the small holders who had been offering at low prices were generally cleaned out. On Aug. 28 an advance to \$23@24.50 was recorded. Thereafter there was a steady advance, \$24@24.50 being quoted on Sept. 4; \$25.50 on Sept. 18; \$26 on Oct. 2; \$27 on Oct. 9; \$27.75 on Oct. 23, and \$28.50 on Oct. 30. An unusually large fall trade developed, especially with jewelers, who took considerable quantities in anticipation of the holiday season. About the middle of November there was an advance to \$29.50 per oz., and this held until the end of the year.

Hard metal, which is an alloy of platinum and iridium, had special advances on account of a scarcity of iridium and its consequent high price. During the first half of the year the difference in price between refined platinum and hard metal was \$2.50 per oz.; in July this was increased to \$3.75, and in December to \$5.50. The dealers' quotation for hard platinum was \$35@35.50 per oz., at the close of the year.

An interesting occurrence of platinum in a primary ore is reported from the Key West and Great Eastern properties in the Copper King district, Clark county, Nevada. The platinum is found in peridotite dikes traversing coarse-grained gneisses, and is associated with nickeliferous pyrrhotite, magnetite, chalcopyrite and pyrite. Beside the peridotite there is also present a typical hornblendite dike which shows upon analysis a trace of platinum. Alteration and concentration of the sulphides in the rock by solution seems to have increased the percentage of platinum and nickel, one analysis showing 0.35 oz. of platinum per ton and over 5 per cent. nickel. The dikes, as exposed upon the surface, vary in width from 10 to 50 ft., and are about 100 ft. long. In 1909 one carload of ore was shipped from the Key West workings.

Platinum Mining in Foreign Countries.

British Columbia.—During the last four or five years placer mining operations in the Tulameen and Similkameen districts of British Columbia, which from 1887 to 1891 produced approximately 2000 oz. of platinum per year, were actively prosecuted by only a few individuals. In consequence the production of platinum from this district fell off until it now amounts to probably less than 50 oz. per year. In 1909, Messrs. Lambert & Stuart carried on the only serious placer mining in the Tulameen district, operating a lease on Granite creek, a short distance above the mouth of the North Fork. Tests of the gravel, which they have been ground-sluicing for the last three years preparatory to cleaning up in 1910, show a proportion of about four parts of gold to one of platinum. A company recently organized in Vancouver, the British Columbia Platinum Company, has obtained from the government three leases in what was formerly the most productive platinum district. One of these leases applies to an area on Slate creek, and the others to areas on the Tulameen river above Slate creek. The company proposes to first prospect the ground with a Keystone drill, and then mine it by ground sluicing or by drifting on bedrock.

Colombia.—While ranking next to Russia in its platinum production, Colombia at present supplies only about 5 per cent. of the world's consumption of the metal. The recent high prices and the gradual depletion of the Russian deposits have of late drawn a great deal of attention to the Colombian deposits. During 1909 two dredges were installed with successful results on placer ground in the platinum-bearing areas, and it is expected that the production of the country will increase rapidly within the next few years. However, there is great difficulty in making any forecast of the future output, not because the country is unexplored or unknown, but because no organized or scientific attempt has yet been made to test the value of the platinum deposits.

Of the two known platinum-bearing areas, which are both situated in the western part of the State, the Choco district is the largest and most important. The chief platinum-bearing zone in this area is drained by the San Juan, l'Iro, Condoto and Tamana rivers. The metal is also obtained from deposits in the Bebara, the Negua and the Andagueda valleys. In 1909, the Mineral Syndicate of the Condoto, a company formed in Bogota, placed a dredge of the Risdon type on the Condoto deposits. The Barbacoas district, which is the other principal platiniferous area, is situated in the southwest corner of the department of the Cauca and extends from the frontier of Ecuador to the Micay river. The gold contained in the placers of this district is of so much more importance than the platinum that the latter is seldom mentioned in accounts of the district. Not even an approximate estimate of the relative percentage of platinum and gold found in the placers can be made. In 1908 an Australian company, which has been granted a concession by the government, built a dredge on the Patia river, and although mining is primarily for gold, the company expects to make a considerable production of platinum.

Russia.—The production of platinum in Russia in 1909 was officially reported as 190,087 oz., as compared with 150,087 oz. in 1908. It is impossible to give figures of actual production, as a large amount (variously estimated from 5 to 15 per cent. of the total production) is stolen, and a still larger quantity is smuggled across the frontier without being registered at the government assay office at Ekaterinburg, which imposes a tax of 3 to 4 per cent. The actual production in 1909 may be safely estimated at 275,000 oz. The accompanying table gives the production as officially reported and the probable actual output for a period of years.

PRODUCTION OF PLATINUM IN RUSSIA.

Year.	Official.	Actual.	Year.	Official.	Actual.	Year.	Official.	Actual.
	oz.	oz.		oz.	oz.		oz.	oz.
1892......	146,806	260,000	1898.....	193,213	203,100	1904.....	161,950	290,120
1893......	163,757	285,850	1899.....	191,464	380,900	1905.....	167,950	200,450
1894......	167,268	203,250	1900.....	163,060	212,500	1906.....	185,546	210,318
1895......	141,757	290,900	1901.....	203,257	315,200	1907.....	172,064	310,000
1896......	158,326	200,000	1902.....	197,024	380,806	1908.....	157,005	250,000
1897......	179,879	395,200	1903.....	192,976	276,000	1909.....	190,087	275,000

The price of crude platinum fluctuated widely during the year. In Ekaterinburg, which is a primary market in which the smaller miners offer their production, the price in January was 5 rubles per zolotnik for crude metal, 83 per cent. platinum. This held until the end of March, when a gradual fall began, the lowest price—4.25 rubles per zolotnik—being reached in June. Recovery from this point was slow for two months, but in September 5.25 rubles was reached; in November 6 rubles and at the close of the year 6.25 rubles. The large producers and the middlemen who buy small lots usually sell their metal in St. Petersburg. The opening price there was 20,550 rubles per pood; the quotation declined until June, when the lowest point of the year was reached, at 18,000 rubles per pood. An advance began in August which carried the quotations to 22,500 rubles in October; 24,000 rubles in November, and 24,500 rubles at the end of the year.

AVERAGE PRICES OF PLATINUM IN 1909.
(In dollars per troy ounce.)

	New York, Refined Platinum.	Russia, Crude Metal—83 Per Cent. Platinum.	
		St. Petersburg.	Ekaterinburg.
January..................	24.10	20.14	18.80
February.................	24.00	19.80	18.89
March....................	23.75	19.09	18.85
April....................	23.50	18.13	17.48
May......................	23.25	18.13	17.86
June.....................	22.75	17.64	16.58
July.....................	22.43	17.64	16.73
August...................	22.65	19.83	19.27
September................	25.31	20.64	19.74
October..................	27.75	21.85	21.53
November.................	29.50	23.52	22.56
December.................	29.50	23.77	23.03
Average for the year.....	24.87	20.02	19.26

The foregoing table gives a comparison of the average monthly prices of refined platinum in New York and of crude metal in the Russian markets. The Russian prices in the table are reduced to their equivalents in United States currency.

During 1909 the Société Anonyme d'Industrie du Platine, of Paris, under the leadership of M. Bonnardelle, succeeded in syndicating the output of the largest operating companies for a long period of years. Approximately two-thirds of the total production is thus directly controlled by the French company, and as it is also the principal purchaser from the small operators, it absolutely controls the Russian output and hence the world's production and markets. The small producers realizing their helpless situation under the domination of the syndicate, held a congress at Ekaterinburg, at which a representative of the Russian Government was present, to determine upon relief measures. One proposition discussed at this congress was to the effect that the Government should prohibit the exportation of crude platinum and buy the entire output at a fixed price, which should be not less than 21,000 rubles per pood for 83 per cent. pure metal; and that the Government should then refine the material in its own laboratories, market the product, and divide the profits over and above the fixed price with the mine owners. Another proposition was that the Government refuse to permit the exportation of crude platinum and guarantee the producers through the Imperial Bank a minimum price of 21,000 rubles per pood for 83 per cent. fine metal, and thus secure the material against the usual fluctuations in price. The producers could then undertake the refining and sales themselves under the best possible conditions.

The two largest producers, the Société Industrielle du Platine and the Petersburger Gesellschaft Platina, completely ignored the congress and the representatives of the important Demidoff and Schuvaloff properties voted against Government control. In fact, those in favor of a State monopoly represented mines producing hardly 3 per cent. of the total output. That the Government will accede to the wishes of the small producers in this matter is therefore hardly to be expected. Moreover, the consumption of platinum in Russia is relatively so small that the Government would be dependent on foreign demand in fixing the price. It could therefore hardly risk guaranteeing the producers a fixed price, even when this was much lower than the originators of the proposition wished. Again, a prohibition of the exportation of crude platinum, which takes place very largely as passengers' baggage or in postal packages, would be impracticable.

With respect to the technical side, 1909 was marked by a considerable increase in the relative output of the dredging operations. The two dredges of English manufacture installed on the Demidoff estate in 1908 were successfully operated in 1909. The total cost of the two dredges erected on the property was approximately £25,000, and the value of the platinum recovered from April 5 to Oct. 25, 1909, amounted to £72,555; that is, the dredges recovered nearly three times their total cost in about six and a half months. Each dredge has a bucket capacity of 7 cu.ft. and is fitted with special buckets and extra water supply for dredging through stiff clay. The recovery was about 2s. per cubic yard.

In an effort to stimulate the search for new platinum deposits the Russian Permanent Geological Committee detailed some geologists to make researches in the northern Urals in 1909. In several places olivine reefs were discovered which carried traces of platinum, but none of these proved to be of industrial value.

AUCTION SALES OF CRUDE PLATINUM AT EKATERINBURG.

Year.	Oz.	Per oz. £ s. d.	Year.	Oz.	Per oz. £ s. d.	Year.	Oz.	Per oz. £ s. d.
1893......	2,700	1 5 10	1899.....	9,000	1 7 8	1905.....	4,950	3 8 6
1894......	5,400	1 6 0	1900.....	4,900	2 8 6	1906.....	6,120	4 0 0
1895......	4,300	1 6 7	1901.....	3,850	2 8 6	1907.....	5,250	4 2 0
1896......	2,800	1 6 8	1902.....	5,300	3 0 6	1908.....	5,750	4 0 0
1897......	7,000	1 6 9	1903.....	4,750	3 3 0			
1898......	5,050	1 7 0	1904.....	6,900	3 5 6			

(By I. I. Rogovin.)—The production of platinum in Russia in 1909 was 190,087 oz. of crude metal containing 83 per cent. platinum. This is an increase of 33,082 oz., or about 21 per cent., over the output in 1908. The gain was made chiefly in the later months of 1909, the activity in mining being stimulated by the larger demand for the metal and the higher prices realized for it.

The concentration of the industry made much progress during the year and the Russian platinum business is now almost completely syndicated. During the year an agreement was completed, the parties to which are the Société Anonyme d'Industrie du Platine, of Paris; Count P. P. Shouvaloff's Successors and the Estate of Prince Demidoff. The terms of the agreement are such that the Société du Platine controls the production and sale of about 85 per cent. of the total Russian production. This excited much feeling among the smaller producers, which found expression in the newspapers. As a result the Government appointed a special commission to inquire into the conditions of the industry. After a number of sessions this commission made a report recommending: (1) That the export of crude platinum from Russia be prohibited; (2) That all platinum mined should be refined in a plant to be built for the purpose either by the Government or by a company specially licensed for the purpose; (3) That the National Bank be authorized to make loans or advances to miners on the metal. These measures were recommended as aids to the smaller producers to enable them to continue at work.

The Russian Platinum Industry.[1]

By E. de Hautpick.

The official figures of the production of platinum in the various districts of the Ural in 1909 are given in the accompanying table. Of the total, 171,120 oz. were produced by hand methods and 18,967 oz. by dredges.

PRODUCTION OF PLATINUM IN THE URAL.
(In troy ounces)

District.	1906	1907	1908	1909
South Verchotur	127,461	121,665	97,879	116,235
North Verchotur	11,156	7,554	13,043	17,120
Perm	40,149	36,082	36,776	46,347
Tcherdinsk	4,450	4,894	7,470	8,325
South Ekaterinburg	2,330	1,869	1,837	2,060
Total	185,546	172,064	157,005	190,087

A marked extension in the use of dredges depends on their being of suitable type to handle ground hitherto unworkable, and also on the facilities for obtaining them on credit or on easy terms. Russian enterprise is so poor in available capital that no matter how advantageous a machine may be, it is done without the moment it cannot be had on credit. In 1904 the production of platinum by dredging constituted 4.4 per cent. of the output. In 1905, 5½ per cent. of the total was washed by dredges, and in 1909 they accounted for about 10 per cent. of the total yield. Due to the protective tariff, most of the dredges in the Ural district are of Russian make and were supplied by the Putiloff company of St. Petersburg, in favor of which establishment the Imperial Bank has opened a special credit for dredge construction.

The average annual production of platinum in Russia is gradually declining. This reduction is explained, first, by the fact that the platinum deposits are gradually becoming exhausted, and second, by the tax on industry, the laws on accidents and timber allowances, the apportionment of land among the peasants and other analogous legis-

[1] Abstract of an article in London *Min. Journ.* March 26, 1910.

lation, which has seriously handicapped the platinum operators. Most of the companies retain the original hand-washing system. There are whole districts, for example, in the Tchedinsk and Solikam areas, where there is not one mechanical motor, and it has even occurred that companies which once used machinery have gone back to hand methods. The large companies are well organized in respect to the sale of their product and their only trouble is platinum stealing, from which the smaller companies also suffer. If the small operators could sell their platinum in a refined state they would be in quite a satisfactory position. To do this they must either apply for Government co-operation or build a refinery of their own.

In 1909 the Société Industrielle du Platine offered to take the platinum output of all small operators on the following conditions: On the delivery of the platinum the company would make an advance of £2 7s. per oz. for crude with an 83 per cent. content of pure metal, and when it was refined and sold the total yield over and above the advance would be given to the mine owner. The profit of the company would consist of 5 per cent. interest per annum on the sum advanced, plus $\frac{1}{4}$ per cent. commission and the value of the associated platinum metals. To insure itself against the agitation of the small operators for a State refinery, the company proposed to build its own factory in the Urals and to refine the platinum of other operators free of charge, retaining the associated metals as its profit. The company at present has a splendidly equipped refinery in Paris which has a capacity of 13,000 oz. per month, which approximately corresponds to two-thirds of the world's requirements.

It is difficult to see what advantage it will be to the small producers to sell their platinum to the Société Industrielle du Platine on the terms stated above. At present the situation of the small producers in general is such that they should combine their interests. While the French syndicate absolutely controls approximately 65 per cent. of the total production through contracts with the large producers, this amount is not sufficient to supply the total consumption. Therefore, the small operators will always have a market for their output and by forming a union, and neither selling or leasing their mines to the syndicate, they can easily obtain remunerative prices for their product.

Bibliography of Platinum in 1909.

Anonymous. "Russlands Platinahandel und Produktion. (*Eisen-Zeit.*, Feb. 27, 1909; ¾ p.)

Castillo, J. C. "Geology of the Platinum Deposits of Colombia." (*Min. and Sci. Press*, June 12, 1909; 2 pp.)

De Hautpick, E. "Russian Platinum Industry and Its Regulation." (*Min. Journ.*, May 8, 1909; 1½ pp.)

Mingaye, J. C. H. "Colorimetric Method for the Estimation of Small Amounts of Platinum." (*Rec.*, Geol. Surv. N. S. W., May, 1909; 3 pp.)

Wöhler, L. "Eine Neue Oxydationsstufe des Platins und ihr Oxyd." (*Zeit. f. Elecktrochem.*, Oct. 15, 1909; 5 pp.)

POTASSIUM SALTS.

By Frederick W. Horton.

There are few known commercial deposits of potash salts outside of Germany, and that country practically supplies the world's production. About 20,000 tons of saltpeter are annually exported from India, and a few tons are also produced in Chile and Austria. Chile could probably supply her own limited needs from deposits in the province of Tara-

PRODUCTION OF POTASSIUM SALTS IN GERMANY. (a)
(In metric tons and dollars: 1 mark=$0.238.)

Year.	Kainit.		Potassium Salts other than Kainit.		Potassium. Chloride		Potassium. Sulphate.		Potassium Magnesium Sulphate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$		$		$
1896	856,290	2,989,736	902,707	2,964,750	174,515	5,718,559	19,682	813,381	4,623	85,977
1897	992,389	3,486,007	953,798	3,030,143	168,001	5,764,423	13,774	565,720	7,812	149,079
1898	1,103,643	3,835,856	1,105,212	3,576,628	191,347	6,380,220	18,853	763,397	13,982	259,485
1899	1,108,159	3,838,250	1,384,972	4,202,000	207,506	6,801,250	26,103	1,027,500	9,765	195,000
1900	1,178,527	4,134,000	1,874,346	5,643,750	271,512	8,793,750	33,853	1,249,250	15,368	280,500
1901	1,500,748	4,327,250	2,036,326	5,443,250	282,750	8,782,250	27,304	1,460,000	15,612	286,500
1902	1,322,633	4,571,980	1,962,384	4,949,448	267,512	7,507,710	28,279	1,079,092	18,147	334,390
1903	1,557,243	5,208,154	2,073,720	4,993,478	280,248	8,125,320	36,674	1,389,444	23,631	441,252
1904	1,905,893	6,322,470	2,179,471	5,305,972	297,238	8,425,676	43,959	1,664,572	29,285	545,972
1905	2,387,643	7,976,808	2,655,845	6,396,250	373,177	10,580,528	47,994	1,804,040	34,222	614,754
1906	2,720,594	8,918,574	2,821,073	6,538,336	403,387	11,034,632	54,490	2,032,520	35,211	644,028
1907	2,624,412	8,579,206	3,124,955	7,314,930	473,138	12,639,704	60,292	2,216,494	33,368	631,652
1908	2,715,487	9,196,082	3,383,535	7,720,006	511,258	13,369,174	55,756	2,037,518	33,149	663,068
1909	3,071,619	10,333,008	3,969,554	9,098,026	629,393	16,123,072	68,539	2,574,684	38,722	697,816

(a) From *Vierteljahrshefte zur Statistik des Deutschen Reichs.*

EXPORTS OF SALTPETER FROM INDIA. (a)
(In tons of 2000 lb.)

Year.	Quantity.	Value.	Value per 100 lb.	Year.	Quantity.	Value.	Value per 100 lb.
1899..........	19,870	$1,281,050	$3.64	1904..........	21,894	$1,331,745	$3.04
1900..........	17,432	1,471,245	4.05	1905..........	17,535	1,178,615	3.36
1901..........	17,721	1,189,400	3.22	1906..........	19,446	1,352,735	3.48
1902..........	21,882	1,359,335	3.11	1907..........	20,025	1,337,000	3.34
1903..........	23,105	1,450,980	3.14	1908..........	21,627	1,424,000	3.29

(a) From "Mineral Production of India," by T. H. Holland, Government Geologist.

paca and from Lake Huasco in the province of Atacama. In Austria the potash deposits, near Kalusz in Galicia, have not been developed sufficiently to supply the domestic demand, and about 500 tons of the salt are imported annually from Germany. Deposits of potash also occur in

Hungary, Russia, Holland and Persia, but these have been worked to only a limited extent. The reported discovery of large deposits of potassium salts in China is of interest, but all particulars, especially as to the situation of the deposits, have been kept secret. The quantity and value of the potassium salts produced in Germany, and of the exports from India, are given in the table on the opposite page.

German Potash Industry.

The fact that Germany enjoys a practical monopoly in the production of potassium salts, favored the organization of the Kali-Syndicate, which controlled the product of all the large mines. This syndicate allotted to each of the participators a certain percentage of the sales, and fixed prices at figures which returned large profits. Agreements to syndicate the production have usually been for periods of five years, and agreements which had heretofore been in operation, expired by limitation on Dec. 31, 1909, but they practically expired on June 30, for the reason that the restriction prohibiting any sales except through the syndicate went out of effect at that time.

For several months prior to that date delegates representing the various mines held frequent meetings in the endeavor to form a new syndicate, but when the appointed hour (midnight, June 30, 1909) arrived, they had failed to reach an agreement, and many of the delegates left the convention believing that the attempt to form a new syndicate was ended. Every member was, therefore, free to make sales on his own account, and some exercised this opportunity before the mandate, issued by the president of the syndicate between 1 and 2 a. m. of that night, to meet again at 9 a. m. was received. During the interim large contracts at prices considerably below those of the syndicate were made by American buyers, who were in Berlin watching the situation. These contracts which were made for delivery over a period of seven years, from Jan. 1, 1910, aggregated over $20,000,000. When these sales were reported in the meeting of the syndicate, the members were demoralized, and the termination of all further negotiation seemed imminent.

After days of deliberation, it was decided to form a provisional syndicate, subject to securing the surrender of these contracts or perfecting some agreement between the contracting parties and the syndicate. Negotiations between all parties concerned continued at intervals to Oct. 1, when, no arrangement having been reached, a new syndicate was formed, excluding the Aschersleben and Sollstedt mines, which had made the principal contracts with the American buyers. The Aschersleben mine is controlled in Germany, but the Sollstedt mine was sold on the night of June 30 to the American Agricultural Corporation.

During the latter part of the year the fight between the German and American interests waged furiously. The Prussian Government, itself a large producer and a leading member of the syndicate, led a movement to nullify the American coup by inducing the Imperial Government to impose an export tax on potash. This obviously was more or less of a bluff, as such a tax would deal a heavy blow to the Germans themselves. Later in the year legislation was in course of preparation providing that the Government regulate export prices by placing a tax on exported potash equal to the difference between the Government schedule and the prices as fixed by the mine owners under the regime of the syndicate. In order to prevent sales at prices below the Government figures, it was suggested that a tax be placed on production when it exceeded the Government allotment.

In view of this proposed legislation, the American interests sought the aid of the United States Government in an effort to protect their contract rights, contending that the German interests were discriminating against American buyers, and that the 25-per cent. maximum tariff clause of the Payne-Aldrich bill should be applied against German imports into the United States. The year closed without any definite solution of the situation being reached.

The consumption of German potash in the United States in 1909 embraces more than one-half of the exported supply and about one-fifth of the entire output. The following figures show the respective amounts in metric tons of the total German exports of various potassium salts and exports to the United States: Kainit, 9,465,141 and 4,699,632; potassium chloride, 2,198,696 and 1,321,975; potassium sulphate, 631,071 and 345,516; potassium magnesium sulphate, 1,383,474 and 638,449 tons.

The Potassium Salt Market in 1909.[1]

Owing to the disturbances referred to above a large number of consumers held off in their purchases until late in the fall, hoping that the syndicate would be dissolved and that lower prices would prevail. However, these things did not materialize and a great rush took place late in November and December. The following schedule prevailed throughout the year and up to Jan. 1 the syndicate had not issued any new price schedule for 1910:

Potassium chloride (80-per cent. basis), $1.90 per 100 ℔.; potassium sulphate (90-per cent. basis), $2.185 per 100 lb., and kainit in bulk, $8.50 per long ton. Manure salt (20-per cent.) sold at $14.75 per ton and the double salt (48-per cent.) at $1.165 per 100 ℔.

[1]Abstract from the *Oil, Paint and Drug Reporter*. Feb, 21, 1910.

Carbonate.—The different grades of carbonate ruled from $3\frac{1}{2}$@$4\frac{3}{4}$c. per ℔. The movement for various consuming purposes was heavy, and a considerable portion of the arrivals found their way to the South. Importations on the whole were free, but the market never weakened materially under the burden. The range in January extended from $3\frac{3}{4}$@$4\frac{3}{4}$c. During the month of May the low point was $3\frac{5}{8}$c., and in August $3\frac{1}{2}$c., this latter price covering sales ex-dock. The high point on both occasions was $4\frac{5}{8}$c. At the close of the year the market was steady on the basis of $3\frac{5}{8}$@$3\frac{7}{8}$c. for 80- to 85-per cent. calcined, $4\frac{3}{8}$@$4\frac{5}{8}$c. for 96- to 98-per cent. calcined, and $4\frac{1}{4}$@$5\frac{5}{8}$c. for 80-to 85-per cent. hydrates.

Caustic Potash.—A steady demand prevailed throughout the year, and dealers experienced little difficulty in maintaining prices at a stationary level. The soap, paper, textile and other large consuming industries showed improved trade conditions, and this influence was reflected in the volume of deliveries on contracts. During the latter part of the year importations were liberal, but the domestic contract movement was sufficient to absorb new goods, and the market was relieved of any unusual pressure. The trading level remained without variation. Ordinary 45- to 90-per cent. was quoted at $3\frac{3}{4}$@$5\frac{3}{4}$c. New process electrolytic 90-per cent. was held at 6c. for 10 drums or more, $6\frac{1}{8}$@$6\frac{1}{4}$c. for lots containing 5 to 10 drums, and $6\frac{3}{8}$c. for single drums or packages amounting to 250 kilograms.

IMPORTS OF POTASSIUM SALTS. (*a*)
(Tons of 2000 ℔.)

	1905		1906		1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bicarbonate	38	$4,504	22	$2,192	155	$6,787	109	$11,500	171	$16,915
Carbonate (crude)	2,634	217,041	2,472	267,865	3,732	266,502	3,903	269,318	4,814	324,540
Carbonate(refined)	6,843	440,139	7,489	451,631	9,326	583,730	8,428	575,731	5,505	379,392
Chloride	101,183	3,241,152	105,938	3,360,804	115,664	3,863,311	118,475	3,885,419	148,669	4,758,907
Chlorate	19	2,352	29	3,868	10	1,486	7	1,052	10	1,655
Chromate	28	3,433	21	3,442	5	685	59	8,447	86	12,330
Cyanide	812	260,208	1,054	321,867	1,535	483,789	1,644	494,915	1,376	386,354
Hydrate (crude)	2,635	217,041	2,473	267,865	3,732	266,502	2,971	241,995	3,521	294,709
Hydrate (refined)	11	2,537	18	3,979	20	4,545	23	4,967	64	9,289
Kainit	240,789	1,143,296	379,221	1,963,914	344,005	2,347,695	329,467	2,008,555	344,526	1,974,165
Nitrate (crude)	....	....	....	....	....	....	8,374	517,334	8,735	512,473
Nitrate (refined)	....	....	....	....	....	....	163	17,487	208	14,421
Prussiate (red)	30	14,453	26	10,300	29	11,811	26	10,697	39	13,522
Prussiate (yellow)	583	103,193	462	85,233	727	148,580	410	88,637	877	178,744
Sulphate	27,289	958,305	24,542	922,171	29,153	1,013,045	28,276	1,030,470	30,508	1,148,607

(*a*) For the fiscal years ending June 30. From the *Oil, Paint and Drug Reporter*, Feb. 21, 1910.

Chlorate.—The trading level, which was established in this item at the beginning of the year, continued throughout without variation. Most of the important business was confined to regular contracts. Late in the year the supply of spot chlorate was nearly exhausted, owing to the urgent request for contract shipments, and jobbers demanded premiums for cash goods. Car lots of crystals held stationary at 8½c., and powdered at 8¾c. f.o.b. works.

Nitrate.—An unusually firm tone characterized trading in both descriptions of this chemical during the greater part of the year. Local supplies of crude were practically exhausted at intervals, and prices were more or less nominal. Supplies of crude on Jan. 1, 1909, were 50 bags, compared to 762 bags for the same period in 1908. All through the winter and early spring local stocks were exceedingly low, owing to heavy contract deliveries. During the summer and fall stocks were replenished, but prices throughout were unchanged. The year's range for crude extended from 4c. to 4½c., while refined was confined within the limits of 5c. to 7c., according to quantity and grade.

QUICKSILVER.

The production of quicksilver in the United States in 1909 showed an increase over that of the preceding year for the first time since 1902. From an inspection of the statistics of the industry, given in the accompanying table, it will be seen that the slight gain in output was due to an increase of production in Texas, Oregon and Nevada. For the first time in many years there was a small output in Nevada, but no production was reported from either Arizona or Utah. There was a notable decrease in the output of the California mines, and it must be confessed that the quicksilver industry of this State is in a rather decadent stage. No new deposits of importance have been discovered in the last ten years, and the older mines, which were large producers in the past, are either working low-grade ores (the average mercury content of the ore treated by the large California mines in 1909 was not over 0.75 per cent.) or have discontinued operations entirely. In view of the steadily declining output of this State, and the fact that there is no reason to expect any large gain in the output of Texas, Oregon, or Nevada, the total production of the country in 1910 will probably show a decrease.

Market and Prices.—While the major portion of the domestic production of quicksilver in 1909 was used for home consumption, there was a

STATISTICS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks	Metric Tons.	Value	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons						
1896	30,765	....	....	1,061	$1,075,449	19,944	692	$618,437	....	$2,037
1897	26,648	....	....	919	993,445	13,173	475	394,549	45,539	20,147
1898	31,092	(b)	153	1,077	1,194,746	12,830	445	440,587	81	51
1899	29,454	261	....	1,025	1,416,790	16,518	573	609,586	131	83
1900	26,317	1,700	233	974	1,279,436	10,702	353	425,812	2,616	1,051
1901	26,720	2,932	75	1,031	1,382,305	11,219	389	475,609	1,441	789
1902	29,552	5,252	....	1,208	1,515,714	13,247	459	575,099	*Nil.*	....
1903	32,094	5,029	....	1,288	1,564,734	17,575	610	719,119	*Nil.*	....
1904	28,876	5,336	700	(c)1,204	1,348,185	21,064	731	841,108	212	160
1905	24,655	5,000	1,050	1,045	1,217,652	13,460	458	497,470	2,690	1,710
1906	19,516	4,517	1,276	861	1,035,138	6,455	220	244,299	84	50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	3,925	810	713	953,410	6,803	231	266,243	15,968	8,203

(*a*) Reported by the California State Mining Bureau, except 1907-08. (*b*) Included in "Other States." (*c*) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (*d*) Figures collected by ***The Mineral Industry***. (*f*) Computed at average price at New York.

QUICKSILVER PRODUCTION OF THE WORLD.
(Metric tons.)

Year.	Austria.	Hungary.	Italy.	Mexico.	Russia.	Spain.	United States.	Total.
1896	564	1	186	218	491	1,524	1,036	4,020
1897	532	1	192	294	616	1,728	965	4,328
1898	491	7	173	353	362	1,691	1,058	4,135
1899	536	27	205	324	360	1,357	993	3,802
1900	510	32	260	124	304	1,095	983	3,308
1901	525	33	278	128	368	754	1,031	3,117
1902	511	45	259	191	416	1,425	1,208	4,055
1903	523	44	314	188	362	968	1,288	3,687
1904	536	45	357	(e) 190	332	1,130	1,192	3,782
1905	519	36	370	(e) 190	318	853	1,045	3,331
1906	526	50	418	(e) 200	210	1,568	963	3,935
1907	527	40	434	(e) 200	130	1,212	712	3,255
1908	572	78	484	(e) 200	47	1,068	685	3,334

(e) Estimated.

notable increase in the amount exported. The California mines no longer have large excess stocks to dispose of, and shipments to China and Japan have practically ceased. The bulk of the exports for the year were to Canada, Europe and Mexico. Imports, as for a long period of years, were insignificant.

The world's price for quicksilver is practically fixed in London by the Rothschilds, who control the product of the most important mine, the Almaden of Spain. The higher domestic prices are due to the import duty which remained unchanged under the Payne tariff at 7c. per pound or $5.25 per flask. The New York price is usually a little higher than the San Francisco quotation, and the export price about $2 less than for domestic consumption. There has been a steady rise in prices during the last three years, and this in the face of the fact that the demand for metallurgical purposes, which is the principal use of quicksilver, has been steadily declining. The adoption of the cyanide process in gold mining, the restriction of hydraulic mining, and the almost complete cessation of the patio process of treating silver ore

QUOTATIONS FOR QUICKSILVER IN LARGE LOTS.

Month.	1906			1907			1908			1909		
	New York.	San Francisco.		New York.	San Francisco.		New York.	San Francisco.		New York.	San Francisco.	
		Domestic.	Export.		Domestic.	Export.		Domestic.	Export.		Domestic.	Export.
Jan.	$40.25	$39.13	$37.63	$41.25	$39.50	$37.50	$45.00	$45.00	$43.50	$45.50	$45.30	$43.30
Feb.	41.00	39.50	38.00	41.25	39.00	37.37	45.00	45.00	43.50	45.50	45.50	43.50
Mar.	41.00	39.50	38.00	41.00	38.50	37.25	45.00	45.00	43.50	45.50	44.75	42.75
Apr.	41.00	39.50	38.00	41.00	38.50	37.25	45.00	45.00	43.50	45.00	44.25	42.25
May	41.00	39.50	38.00	41.00	38.50	37.25	45.00	44.50	43.50	44.50	44.00	42.00
June	41.00	39.50	38.00	41.00	38.50	25.37	44.25	44.00	42.50	44.50	44.00	42.00
July	41.00	39.50	38.00	41.00	38.50	25.37	44.00	43.50	42.00	43.75	43.44	41.44
Aug.	41.00	39.50	38.00	40.00	38.00	36.75	43.30	42.70	41.30	43.75	42.95	40.95
Sep.	41.00	39.50	38.00	40.00	38.05	36.70	42.87	42.25	40.50	45.00	43.50	41.50
Oct.	41.00	39.50	38.00	40.50	38.19	36.50	46.25	43.50	41.62	47.00	45.90	43.90
Nov.	40.75	39.50	37.50	45.00	45.00	43.50	46.60	44.50	42.50	52.50	50.75	48.75
Dec.	40.75	39.50	37.50	45.00	45.00	43.50	45.75	45.12	43.12	52.50	51.00	49.00
Year.	$40.90	$39.47	$37.89	$41.50	$39.60	$38.17	$44.84	$44.17	$42.54	$46.30	$45.45	$43.45

has materially reduced consumption for these purposes. The recently augmented demand appears to be due to an increased use for fulminates, drugs and pigments. The price of these materials was advanced during the year in sympathy with the increased cost of their basic content.

Quicksilver in the United States.

By H. W. Turner.

California.—There was a notable decrease in the production of quicksilver in California in 1909. Two of the oldest producing mines of the State have closed down during the last two years, and two others, the Great Western of Lake county and the Napa Consolidated of Napa county, are making their final cleanups; while still another, formerly a very important property, is working very low-grade ore. No new deposits of importance were developed in 1909, although some promising prospects may prove to be valuable. In San Benito county the New Idria Quicksilver Company maintained its usual output and was the largest producer in the State. Its report for the year 1909 shows that 67,247 tons of ore were mined and treated; the yield being 8900 flasks of quicksilver, an average extraction of 9.92 lb. per ton or 0.496 per cent. The average earnings per flask of quicksilver were $39.85; expenses, $27.53; leaving $12.32 net earnings.

The cost of mining and treating a ton of ore was $3.14 and the profit per ton $1.63. From the accumulated earnings the company declared a dividend of 24 per cent., amounting to $120,000. During the year two furnaces were run continuously, and part of the time three, No. 2 having been closed for repairs in the spring.

In Lake county the furnace of the Helen mine produced a large amount of soot, which is now being retorted. The Chicago, just east of the Helen, found considerable ore. The Wall Street, adjoining the Chicago, ran one D-retort during part of the year on ore from that mine. In Sonoma county the Culver-Baer, formerly known as the Oakland, has a good body of ore. In Napa county, a retort is said to be in operation at the Etna mine in Pope valley and considerable ore is blocked out. The report of the Napa Consolidated Quicksilver Company for 1909 gives the ore reduced for the year at 18,583 tons, from which 1605 flasks of quicksilver were recovered; an average yield of 0.32 per cent. The average receipts per flask of quicksilver were $38.75, and the expenses, $34.69. The property of this company was closed down early in the autumn, as further prospecting for new ore bodies was considered unadvisable. During the latter part of the year the company was occupied in roasting the ore on hand and cleaning up around the furnaces. In Santa Clara county the New Almaden furnaces treated 0.2- to 0.3-per cent. ore. In Modoc county a discovery of cinnabar was reported in the Willow Creek district, near Goose lake.

Nevada.—At the mine of the Shoshone Quicksilver Mining Company, which is situated about three miles northeast of Berlin, Nye county, a 30-ton furnace is being installed. There are two veins on the property and it is reported that there are 500,000 tons of probable ore in sight which will carry 2 per cent. mercury. The ore is found chiefly in rhyolite near limestone, and to some extent in the limestone. The mercury is present as cinnabar, metacinnabarite and calomel. At present much of the ore is being taken from an open cut. After sizing on a fine grizzly, it is hand-sorted to a 6-per cent. grade and roasted in nine D-retorts, 8 ft. long and 2 ft. wide. These retorts treat about 5½ tons daily. There is almost enough lime in the ore to make it self-fluxing, so that little trouble is experienced from sulphur affecting the retorts. Before each charge is drawn the retort is blown with air to oxidize the free sulphur. Some of the sulphur re-unites with the quicksilver forming a dark brown sulphide.

Two prospects are being developed in Humboldt county. One, known as the Ruby mine, is in Eldorado canyon four miles east of Valley siding on the Central Pacific railroad, and the other in American canyon 14 miles easterly from Oreana. Some new discoveries of cinnabar were made east of Goldfield and between Berlin and Austin. Their extent has not yet been determined.

Oregon.—The Blackbutte mine in Lane county furnished a considerable production in 1909. A furnace using producer gas as fuel was placed in operation at this mine in 1908. This new furnace has been described by W. B. Dennis,[1] as has also the down-draft producer-gas plant. The furnace consists of a tower or shaft divided by means of tiles of an inverted V-shape and grate bars into a number of compartments. The grate bars are operated from the charging floor by means of levers and the ore dumped from a higher compartment to the one next lower. Mr. Dennis claims that his furnace will roast a given amount of ore in a much shorter time than the Scott furnace, which is the one in most general use.

Texas.—The condition of the quicksilver industry in Texas was recently reviewed by William B. Phillips.[2] There are seven furnaces in the Terlingua district, of which one of the Marfa & Mariposa and that of the Chisos Mining Company were in operation. The two furnaces of the Marfa & Mariposa Company are called 10-ton furnaces although they treat 12 tons per day each. The Chisos company operated for several years with D-retorts, but in 1908 built a 20-ton Scott furnace which was in commission in 1909, and in consequence the company

[1] *Eng. and Min. Journ.*, LXXXVIII, 112-116.
[2] *Ibid.* LXXXVIII, 1022-1024.

treated a lower grade of ore, as was also done in 1908 in the Tignor furnace.

There are two main geological horizons in the district that contain mercury deposits: The Lower Cretaceous (Edwards limestone) and the Upper Cretaceous (Eagle Ford shale). The ores of these two formations differ to some extent. The ores in the Edwards limestone contain considerable yellow ore and native mercury, the yellow ore being oxychloride of mercury. Nevertheless the ordinary ore is cinnabar with calcite, gypsum, and sometimes pyrite, and traces of bitumen. The ores of the Eagle Ford shales, which are bituminous, contain much hydrocarbon and when treated in retorts yield considerable oil and illuminating gas. Phillips records the discovery of oxychlorides of mercury in the Eagle Ford shales, six miles east of California hill. Previously all the ore found in these bituminous shales was cinnabar. Thus far much the larger part of the production has come from deposits in the Edwards limestone, but the Chisos mine is now finding ore in depth and its future looks promising.

The growing scarcity of wood fuel would be alarming (the district is 90 miles from the railroad and hence the use of oil fuel is not practicable) were it not that there are beds of lignite in Brewster county, not far from the quicksilver mines. This coal is suitable for making producer gas, which, as already referred to, has been used successfully in quicksilver reduction by W. B. Dennis, at Blackbutte, Oregon. The use of gas should moreover greatly reduce the quantity of soot in the condensors, which is much to be desired. Phillips estimated the total cost of producing mercury in the Terlingua district at $25 per flask of 75 ℔. The total production of the Terlingua district to date is given as 40,000 flasks.

In 1905, the legislature of Texas passed a law which practically stopped prospecting on the State lands. The prospector was required to make application for the land wanted, after which the land commissioner fixed the price. Thus if a prospector stumbled on a rich find the commissioner could put on such a price as would prevent a profitable operation. The law of 1909, however, fixes the upper limit at $25 per acre.

Quicksilver in Foreign Countries.

Austria.—The quicksilver mines of Sagron-Miss in the Tyrol and the reduction furnaces at Sagron were idle during 1908. The entire production of the metal, which mounted to 572 metric tons, valued at $616,168, was limited to the province of Idria. The output of quicksilver ore was 90,145 metric tons, an increase of 775 tons over the production in 1907.

China.—According to the Imperial Chinese Maritime Customs, imports of quicksilver into China in 1908 were 40 metric tons and exports during the same period were 44 metric tons.

(By T. T. Read.)—There was a remarkable increase in the production of quicksilver in China in 1908, the output being nearly three times what it was in the immediately preceeding years, a total of nearly 65 tons. The concession of the foreign company which was working quicksilver deposits in Kuei-chou expired during the year, and although the company has asked for an extension of the concession I understand it has been refused. A description of the deposits and methods of working was given in Vol. XVII of THE MINERAL INDUSTRY.

Honduras.—In 1909 a small production of quicksilver in Honduras was derived from mines undergoing development. Exports for the fiscal year ended Aug. 1, 1909, amounted to 138 flasks. The discovery of a rich cinnabar vein in the department of Comayagua was recorded during the Spanish occupation but to date this deposit has not been exploited.

Italy.—Quicksilver mining at Monte Amiata in Tuscany was active in 1908, the production amounting to 684 metric tons, valued at $704,424, as compared with 434 tons valued at 419,086 in 1907. The quantity of ore mined in 1908 was 82,534 metric tons against 76,561 tons in the previous year. Figures of production for 1909 are not available, but exports of the metal for the year showed a steady growth, amounting to 714 metric tons as compared with 565 tons in 1908, and it may be assumed that there was a proportional increase in the production.

According to a report by Mr. Nicou,[1] the columnar deposits of cinnabar in the Monte Amiata district contain 1 per cent. mineral (60 per cent. mercury). The ore is screened, and all the small fragments less than 1½ in. are roasted in Cermak furnaces. The chief mine is that of Abbadia San Salvatore, which turns out about 25,000 tons of 1-per cent. ore yearly. Altogether, the number of furnaces running is 28, among which are seven Cermak furnaces with a capacity of 24 to 30 tons, four of 12 to 15 tons' capacity, four of 2 to 8 tons' capacity, and 13 ordinary 6-ton furnaces. The average recovery from a large furnace is 95.2 per cent. of the total mercury contained in the ore. The latter costs 13s. 6d. to 22s. 6d. per ton at the mine, and the cost of classification, conveyance, and treatment is 3s. 3d. per ton, making the total cost 16s. 9d. to 25s. 9d. for the 12¾ lb. of mercury recovered, or 1s. 4d. to 2s. per lb. Although the quality of the ore is diminishing, the use of improved appliances enables the output of mercury to be maintained, and even increased.

[1] *La Metallurgie*, April 21, 1909.

Mexico.—In 1909 Mexico continued to produce a small amount of quicksilver, principally from deposits in the State of Guerrero. For a number of years the production has been much less than the consumption and imports have amounted to about 200 metric tons annually. There are no statistics as to the number of quicksilver mines actually in operation in Mexico, nor as to the domestic production. The only exportation during 1909 was one lot of 363 kg. sent to the United States. The diminution in the supply of workable quicksilver ores in California and the failure of the Texas district to become a large producer has turned attention to the Mexican deposits and there are numerous occurrences of quicksilver ore in the country which are now being investigated.

The ore from the San Simon and San Esteban mines in the Bella Union field in Guerrero contains about 2.1 per cent. of mercury; but on an average that extracted from the other mines in the district carries only 0.2 to 0.5 per cent. A two-furnace smeltery erected in this field some years ago failed to yield satisfactory results, about 40 per cent. of the mercury being lost in the process of smelting. In general, both the mining and reduction of quicksilver ores in Mexico has been conducted on a small scale and owing to wasteful metallurgical processes only high-grade ore has been available, but inasmuch as ores containing as low as 25 per cent. mercury are profitably treated in Europe and California, the Mexican deposits which were of too low grade to be of value to their former operators are now becoming attractive.

(By Kirby Thomas.)—During the Spanish regime in Mexico the production of quicksilver was directly encouraged, and for a time controlled by the Government in the interest of the silver miners who used it in the treatment of silver ores by the patio process. As a result, the quicksilver deposits of the country were extensively developed and actively operated from the latter part of the 17th century until the suspension of mining activities incident to the political and economic disorganization which arose from and succeeded the war of Independence (1810-1822). Under the Republic there has been some production of quicksilver to supply the patio process operations, which were continued extensively until very recently. The production has not for many years been equal to the demand and Mexico has afforded a good market for California quicksilver up to the present time. Now, however, the reduced demand arising from the general substitution of cyanidation for the patio process and the resumption of operations in several of the Mexican quicksilver localities has practically changed trade conditions and Mexico is likely henceforth to be a considerable producer of quicksilver, instead of a consistent and large importer of the metal. Already some lots have appeared in the

New York market from Mexico and the probability of increased production and continued decrease in consumption in Mexico are new factors in the quicksilver market. During the past few years large stocks of quicksilver held by mining companies which have substituted the cyanide for the patio process have been offered in the market at low prices.

The principal present production of quicksilver in Mexico comes from the Dulces Nombres mine at Moctezuma in San Luis Potosi, from Huitzuco in Guerrero and the Santa Rosa mine in Morelos. The last deposit was acquired by a new company and a 10-ton Scott furnace installed during 1909. The Dulces Nombres mine is treating ore containing more than 3 per cent. quicksilver and has large dumps of lower grade material. This operation is described in an article by P. A. Babb in the *Eng. and Min. Journ.*, Oct. 2, 1909. Deposits of quicksilver ore are found at Guadalcazar and Mezquital in San Luis Potosi, near Pinos in Zacatecas, and in Durango. The Zacatecas deposit is being developed by E. L. Porch of San Antonio, Texas. In most of the Mexican deposits the higher grade ore has been mined under the stimulus of the early demand but much low-grade ore is available in most cases, and generally very little exploration has been done in connection with any of the older deposits. The introduction of economical and systematic mining methods and the installation of modern treatment plants undoubtedly will result in profitable quicksilver operations in several Mexican districts now idle and in an increased output from the few mines now operating.

The important Mexican quicksilver deposits were all formed incidental to extensive thermal spring action resulting from the geologically recent plutonic activity and occur generally in limestone (except in a Durango locality). The quicksilver is generally accompanied by gypsum and often by antimonial minerals. At Huitzuco and Guadalcazar complex antimonial mercury minerals abound. Quicksilver is found native in the Santa Rosa mine, in Morelos.

Peru.—The enormous deposits of quicksilver ore in the vicinity of Huancavelica, Peru, have been worked intermittently since the year 1571. The Santa Barbara mines, situated about two miles southeast of Huancavelica, commenced production at that date and up to 1840 made a recorded total output of 113,382,541 lb. Since 1840 activity in quicksilver mining has practically ceased, due to foreign competition, and from that date to 1909 inclusive, the mines are credited with an estimated production of only 1,000,000 lb. At present only a quintal or two per month is produced, which is used locally by silver miners in the patio process.

The Huancavelica cinnabar belt is said to be about 60 km. long in a northwest and southeast direction, the Santa Barbara mines occupying only a small portion of the entire area. The cinnabar occurs as impregnation deposits in sandstone, limestone and calcareous conglomerates. With cinnabar and native mercury small deposits of galena, sphalerite, pyrite, arsenopyrite and realgar are associated. The ore from workings which have been exploited averages about 2 per cent. mercury. The reduction of the ore was carried on in extremely crude furnaces which even to the present time have varied but little in design from the original ones employed in 1571. It is estimated that in the smelting operations, which have extended over nearly three and one-half centuries, fully 80 per cent. of the mercury in the ores treated was lost.

The revival of the quicksilver industry in Peru depends entirely upon obtaining ample transportation facilities to the mines. At present Huancayo is the nearest shipping point on a railroad, but a line is being built from this place to Iscuchaca which should be opened for traffic in 1912. The terminus of this line will be within 30 miles of Huancavelica.

Spain.—The production of quicksilver in Spain in 1908 was 1,068,588 kg. for 30,937 flasks, valued at $1,387,986. Of this amount 29,472 flasks were from the famous Almaden mine and 1465 flasks from the mines at Micares. In 1907 these same mines produced a total of 1,212,371 kg., or 35,141 flasks, showing a decrease in the 1908 output of 4204 flasks. The amount of quicksilver ore mined in 1908 was 42,210 metric tons. While official figures for the production of quicksilver in 1909 are not available the exports for the year were 1503 metric tons as compared with 1515 metric tons in 1908, indicating but little change in the magnitude of the industry.

Bibliography.

Among the many papers on quicksilver that appeared during 1909, the following are noted:

Babb, P. A. "Dulces Nombres Quicksilver Deposit, Mexico." (*Eng. and Min. Journ.*, Oct. 2, 1909; 3 pp.)

Dennis, William B. "Shortening the Roasting Period for Mercury Ores." (*Eng. and Min. Journ.*, July 17, 1909; 5 pp.)

Desha, L. J. "An Apparatus for the Purification of Mercury." (*Am. Chem. Journ.*, Feb., 1909; 3 pp.)

Dinsmore, Charles A. "Quicksilver Deposits of Brewster County, Texas." (*Min. Wld.*, Oct. 30, 1909; 2 pp.)

Easley, C. W. "Atomic Weight of Mercury." (*Journ.* Am. Chem. Soc., Nov., 1909; 13 pp.)

Janda, F. "Rohstupp vom Schuttofen Nr. III der k.k. Quecksilberhutte in Idria." (*Oest. Zeit. f. B. u. H.*, Oct. 16, 1909; 4½ pp.)

Phillips, W. B. "Condition of the Quicksilver Industry in Texas." (*Eng. and Min. Journ.*, Nov. 20, 1909; 3 pp.)

Prather, J. K. "Mining Quicksilver; Metallurgy of Cinnabar." (*El Paso Min. Journ.*, Oct., 1909; 1 p.)

Strauss, L. W. "Quicksilver at Huancavelica, Peru." (*Min. and Sci. Press*, Oct. 23, 1909; 2 pp.)

SALT.

By Frederick W. Horton.

The production of salt in the United States in 1909 showed a slight increase over the output in 1908. The principal producing States in the order of their importance were Michigan, New York, Ohio, Kansas and California. The statistics of the industry for a period of years are given in the tables on this and the opposite page.

PRODUCTION OF SALT IN THE UNITED STATES. (*a*)
(In barrels of 280 lb.)

Year.	California.	Illinois.	Kansas.	Louisiana.	Michigan (*c*)	Nevada.	New York (*c*)	Ohio, W. Virginia and Pa. (*b*)	Utah.	Other States.	Total Barrels.
1900..	621,857	(*d*)	2,233,878	(*d*)	7,210,621	(*d*)	7,897,071	1,669,156	249,128	987,631	20,869,342
1901..	601,659	99,700	2,087,791	451,430	7,729,641	13,781	7,286,320	1,385,257	334,484	569,092	20,566,661
1902..	682,680	90,009	2,158,486	399,163	8,131,781	14,829	8,523,389	2,318,579	417,501	1,112,824	23,849,221
1903..	629,701	(*d*)	1,555,934	568,936	4,297,542	(*d*)	8,170,648	3,043,135	212,995	489,238	18,968,089
1904..	821,557	(*d*)	2,161,819	1,095,850	5,425,904	(*d*)	8,600,656	3,030,829	253,829	639,558	22,030,002
1905..	664,099	(*d*)	2,098,585	1,055,186	9,492,173	(*d*)	8,359,121	2,728,709	177,342	1,390,907	25,966,122
1906..	806,788	(*d*)	2,198,837	1,179,528	9,936,802	11,249	8,978,630	3,436,840	262,212	1,361,494	28,207,743
1907..	626,693	(*d*)	2,667,459	1,157,621	10,786,630	6,459	9,657,543	4,007,390	345,557	464,143	29,719,493
1908..	899,028	(*d*)	2,588,814	947,129	10,194,279	9,714	9,005,311	3,572,635	242,678	1,291,042	28,754,630
1909..	869,743	....	2,360,000	....	....	....	9,722,127	....	264,657	....	....

(*a*) Statistics of the U. S. Geological Survey except for 1909, and for New York since 1905, which were taken from reports of the State Geologist. (*b*) The production of Pennsylvania since 1905 is included in "Other States." (*c*) Includes brine used in manufacture of alkali. (*d*) Included in "Other States."

Salt Mining in the United States.

California.—In 1909 the production of salt in California was 155,680 tons, valued at $414,708, as compared with 121,764 tons, worth $281,469 in 1908. By far the largest part of the output was obtained by solar evaporation, but steam was used as an accessory at some of the plants.

Kansas. (By Samuel Ainsworth.)—Salt is obtained in Kansas by evaporation processes and by mining rock salt. The evaporated salt business has been largely developed at Hutchinson and evaporating plants are far more numerous than rock-salt mines. This paper, however, deals only with the rock-salt mines.

In 1887 and 1888, the large Kansas salt beds were found while drilling for oil and gas in Ellsworth, Lyons, Hutchinson, Great Bend, Kanopolis, Sterling, Kingman, Anthony and Wellington. The salt bed in all of these drill holes was found to be from 50 to over 400 ft. thick. Various shafts were started at this time, but lack of mining experience and funds caused most of them to be failures.

In 1888, the Kingman Salt Company put down a shaft and operated a mine for two years, when the company failed. Another shaft was put down at Kingman in 1890, but in 1893 operations were suspended. Nine years later, the mine was pumped out and re-opened. This mine has operated since then and a large amount of salt has been taken out. In December, 1908, the mine buildings were destroyed by fire and at present the workings are filled with water. The condition of the shaft and of the mine in general make it improbable that the mine will ever be operated again. Only three other salt mines in Kansas have ever produced salt to any extent and they are: The Bevis Rock Salt Company's mine, at Lyons, and the mines of the Royal Rock Salt Company and the Crystal Rock Salt Company at Kanopolis.

Two shafts were sunk at Lyons, one by the Bevis Rock Salt Company in 1890 and the other by the Midland Rock Salt Company in 1892. The Midland Rock Salt Company reached the salt bed, but failed financially

CONSUMPTION OF SALT IN THE UNITED STATES.
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1897	2,236,248	$4,920,020	209,025	$565,038	5,797	$52,320	2,439,476	$5,432,738
1898	2,465,769	6,212,554	185,530	588,653	8,640	63,624	2,642,659	6,737,583
1899	2,759,206	6,867,467	189,051	579,682	12,600	86,465	2,935,657	7,360,684
1900	2,921,708	6,944,603	199,909	634,307	7,511	65,410	3,114,106	7,513,500
1901	2,879,332	6,617,449	201,733	676,324	9,433	86,414	3,071,632	7,207,359
1902	3,338,892	5,668,636	184,764	647,554	5,094	55,432	3,518,562	6,260,758
1903	2,655,532	5,286,988	165,981	495,948	12,750	95,570	2,808,763	5,687,366
1904	3,084,200	6,021,222	166,140	467,754	13,964	113,625	3,236,376	6,375,351
1905	3,635,257	6,095,922	161,159	492,189	34,238	239,223	3,762,178	6,348,888
1906	3,944,133	6,658,350	170,505	502,583	33,988	274,627	4,080,650	6,886,306
1907	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040

PRODUCTION OF SALT IN FOREIGN COUNTRIES.
(In metric tons.)

	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
Algeria	17,378	18,325	18,518	27,263	26,329	18,563	27,000	22,615	20,400	25,215
Austria	342,059	330,277	333,238	310,807	359,014	369,877	343,375	378,912	395,053	388,133
Canada	53,847	56,296	53,927	57,203	56,671	62,411	41,170	69,291	73,858	81,259
France	1,193,532	1,088,634	910,000	863,927	967,531	1,153,754	1,130,000	1,335,410	1,226,000	1,099,856
Germany	1,432,181	1,514,027	1,563,811	1,583,458	1,693,935	1,701,654	1,777,557	1,870,212	1,950,689	1,997,635
Greece	22,411	22,411	23,079	25,200	26,000	27,000	25,201	25,167	26,966	23,988
Hungary	182,593	189,363	(*a*)211,321	174,882	183,327	187,620	195,410	201,369	395,000	(*c*)
India (*d*)	977,240	1,021,426	1,120,187	1,056,899	908,911	1,188,900	1,212,600	1,176,324	1,120,453	1,300,480
Italy	28,842	367,255	435,187	458,497	488,506	464,326	437,699	496,872	505,000	513,070
Japan	390,433	669,694	659,118	620,820	657,489	701,965	483,506	484,000	(*c*)	(*c*)
Russia	1,681,362	1,768,005	1,705,922	1,847,019	1,658,938	1,908,275	1,844,678	1,730,934	1,873,171	1,879,717
Spain	598,108	450,041	345,063	426,434	427,394	543,674	493,451	541,978	605,895	822,677
U. Kingdom	1,945,531	1,873,601	1,812,180	1,924,273	1,917,184	1,921,899	1,920,149	1,996,593	2,016,510	1,873,555
U. States	2,522,610	2,651,278	2,612,204	2,409,174	2,408,646	2,797,461	3,297,285	3,578,061	3,773,781	3,742,726

(*a*) Sales by the royal monopoly, including imports entered for consumption. (*c*) Statistics not yet published. (*d*) Does not include the untaxed output of certain native States.

and no salt was ever hoisted. The Bevis Rock Salt Company commenced to hoist salt in 1890 and has been in operation continuously up to the present time. At Kanopolis, two shafts were put down, one by the Royal Rock Salt Company in 1891 and another by the Crystal Rock Salt Company in 1908. The former company has worked only part of the time, but at present the mine is in operation. The Crystal Rock Salt Company has been operating since the fall of 1908. Shafts were also started at Ellsworth, Marquette and Little River, but all were failures.

The large rock-salt beds of Kansas are in the Permian formation, with the Marion group of limestones and shales below, and the Wellington above. Only the eastern limit of the bed is known and how far it extends west, north and south has never been ascertained. We know, however, that it extends across the State north and south and is at least 70 miles wide. The salt bed is thickest in the southern portion of the State. At Kingman and Anthony it is over 400 ft. thick; at Hutchinson, 380 ft.; at Lyons, about 275 ft. and at Kanopolis, 230 ft. However, the separate salt seams are thickest in the northern part of the field, and there is less shale in the bed than there is in the southern end.

The shaft of the Bevis Rock Salt Company passed through 14 workable seams of salt and the company decided to work an 18-ft. seam near the bottom of the deposit. The room-and-pillar system of mining is used and the pillars are left permanently. The rooms are 50 ft. wide and 17 ft. high. These rooms are driven parallel to each other and crosscuts are driven every 75 ft., thus leaving a solid pillar 50 ft. wide and 75 ft. long. No timbering is necessary.

In mining a heavy type of machine pick is used, and the salt is first undercut to a depth of 3½ ft. The drilling is done with compressed air auger-drills and 5-ft. holes are put in. A 20-per cent. nitroglycerin powder is used and all the holes in a room are fired simultaneously by electricity, often breaking 500 tons in one blast. The salt is then loaded into mine cars and hauled to the shaft by mules. The salt seam mined is uniform in thickness. A small amount of it is left as a floor and from 12 to 18 in. is left as a roof. Thus the mine has a solid salt floor and roof and there is little chance for shale to get into the salt. About three acres are mined out each year. The mine has a capacity of over 700 tons per day of ten hours, but at the present time the demand is small and about 250 tons are hoisted daily.

The mine has duplicate mills, both being used only when trade demands a large output. In each mill the salt is dumped into a hopper and passes through a set of 24x30-in. toothed rolls. There is a set of movable bars over these rolls and the large lumps are sent over the crusher to a lump chute where they slide down to the ground floor of the mill ready for the railroad cars. The salt that passes through the first set of rolls falls on a shaker containing two screens. Three sizes of salt are obtained from this shaker; the oversize on the first screen goes to a set of 34x20-in. corrugated rolls. After the salt passes through these rolls it goes to a pair of shakers and from these shakers it passes to bins by means of elevators and chutes. Fine salt is made by regrinding the coarse salt in a cyclone crusher.

The shaft of the Royal Rock Salt Company is 803 ft. deep and the seam of salt mined is 9 ft. thick. The main headings in this mine are driven north and south and are 40 ft. wide. The mine is worked similar to the Bevis Rock Salt Company's mine, but no undercutters are used and the salt is blasted off the solid. The mill of the Royal Rock Salt Company is single, and seven sizes of salt are made. These grades are the same in size as those made in all Kansas rock-salt mills. The salt, when hoisted, is dumped on a set of grizzlys and the fine salt passes through to a shaker. The large lumps are fed through a pair of 24x30-in. toothed rolls. From these rolls it is fed directly to a second pair of toothed rolls, set closer together, and from these rolls it goes to three five-screen shakers. The salt from these shakers is stored in bins where it can be loaded directly into railroad cars. The mill has a capacity of about 250 tons per day.

The mine of the Crystal Rock Salt Company is about ¼ mile southwest of the Royal mine and in the same seam of salt. This mine has only been in operation about a year and the workings only extend a few hundred feet from the shaft. The mining operations here are the same as in the Royal mine. Electric drills were tried but they did not prove satisfactory and compressed air auger-drills are now used. The mill of the Crystal Rock Salt Company is double, each unit being similar to the mill of the Royal Company. About 600 tons of salt can be crushed daily, with both sides of the mill running; but at present only one mill is used and about 250 tons of salt are ground daily.

The growth of the Kansas rock-salt business is slow. At no time of the year is the demand so great that the present mines could not supply it. In fact, two salt mines could easily supply the consumption. There is no fixed price obtained for this salt and the rock-salt companies bid against each other for contracts. The Kansas rock salt is quite pure. samples taken from the bins of the various mills averaging over 98 per cent. sodium chloride. The impurities, however, are dark in color and for this reason rock salt is little used for domestic purposes. This salt is used largely by packing houses, stockmen, in making freezing mixtures, by soap makers and by various other manufacturers. There is an unlimited supply of salt in the field and the probabilities are that the production of salt, in Kansas, will increase more rapidly in the future.

(By C. M. Young.)—The evaporated-salt industry has its center at Hutchinson. There are, however, many plants in the surrounding territory. Some of these are evaporating plants only, while in others the evaporation of brine accompanies other enterprises, exhaust steam being the source of heat for the evaporation process. In all cases the brine is obtained from wells. A $5\frac{5}{8}$-in. casing is driven for about 200 ft., being bedded in shale. A $2\frac{1}{2}$-in. pipe extends from the top nearly to the bottom of the well. Water pumped down through the small pipe becomes saturated with salt and flows out of the casing. As more salt is dissolved the surface exposed to the water becomes larger and the capacity of the well increases. An old well will produce about 200 gal. of brine per minute, bearing 2.19 lb. of salt per gal. The solar process of evaporation without the use of artificial heat has been almost entirely abandoned.

Of the processes in which artificial heat is employed, the oldest and simplest is the direct-heat process. In this there is no use of steam, either live or exhaust, but the pans are heated by fires beneath them. The pans, made of sheet iron $\frac{3}{16}$ in. thick, are 24 to 25 ft. wide and 85 to 115 ft. long. They are supported on brickwork and heated by direct firing below. As the water evaporates the salt crystallizes out and collects on the bottom. It is raked by hand labor onto a sloping drip board, a large hoe being used. As the temperature of the pan bottom is quite high the formation of a scale of calcium sulphate gives a great deal of trouble. This scale has to be broken loose and removed by hand. The direct-heat process has been almost entirely superseded by the grainer and vacuum processes which are considerably more economical.

The grainer process, as it was developed in Michigan and introduced into Kansas, is as follows: A pan of about the same form as used in the direct-heat process is employed. In this pan is placed a steam coil of 3-in. pipe suspended from timbers extending across the pan. Generally eight lengths of pipe are used. The low-pressure steam enters at the middle of the tail end, divides and passes through the coils on each side and is trapped out at the head end. As the process was first used the salt was raked out by hand upon dry boards, as in the direct-heat process.

At present this method of removing the salt has been abandoned and mechanical rakes are used. These consist of frames hung on wheels, which run along tracks on the sides of the pans. The frame over each pan carries at intervals of about $9\frac{1}{2}$ ft. a swinging rake which runs below the pipes and when in its lowest position, not quite vertical, scrapes the bottom of the pan. The frame is given a reciprocating motion and, as the rakes move toward the head of the pan, the salt is carried in that direction. When the motion is reversed the rakes tip upward and ride over the salt. The rakes are driven by hydraulic plungers, by pitman and gear, or by rack and pinion. In this way the salt is carried up the drip board, and in some plants is pushed from the dry board upon a belt conveyer which carries it to the curing room. The travel of the rakes is such that there is a lap of about 1 ft. As hand labor is thus reduced to a minimum, the labor cost of the process is low. ,

The heat of the pipes causes the deposition of calcium sulphate, but as this is deposited on the pipes instead of on the pan bottom, its removal is probably less difficult than it otherwise would be. Naturally, the grainer process tends toward the formation of rather large crystals and crystal masses. This is especially true in the old hand-raking process in which the salt is lifted, or raked out, only six or seven times in 24 hours. The agitation caused by the mechanical rakes partly overcomes this difficulty. In the older processes in which the salt had a good opportuity to drain, it carried comparatively little water. In the modern plants the salt is carried by elevators to the curing floor. These elevators are in most cases of the link-belt type with wire-cloth buckets which allow the salt to drain.

The salt remains on the curing floor from 20 to 60 days and during this time the heaps settle several inches, the salt becoming so compact that it has to be broken up with picks. Most of the salt is packed directly from the heap into barrels holding 280 ℔., or into sacks holding 50 ℔. A portion is loaded directly into box cars. It would be desirable to have a mechanical loader to do this work, but none has yet been designed.

A portion of the salt, intended for dairy and table use, is dried in revolving kilns. These are of wood, about 6x40 ft., slightly inclined and fed at the upper end by a mechanical elevator. Inside the wooden drum is a smaller steel drum heated by steam. Flights on the inside of the wooden drum elevate the salt which falls upon the hot steel drum. The moisture is carried away by an air current which also removes a large part of the dust.

In the modern plants, having the best equipment, the vacuum process is used. In this process the brine is heated in an airtight vessel and the steam condensed. The partial vacuum thus produced lowers the boiling point and permits a greater evaporation per pound of steam used than is possible with the grainer process. The vacuum process apparatus is costly, and is, therefore, used only by the large producers. For a detailed description of the two types of vacuum apparatus used the reader is referred to the original article.[1]

Michigan.—According to the annual report of the State salt inspector, the total amount of salt manufactured in Michigan, for the year ending Dec. 1, 1909, was 6,293,490 bbl., an increase of 182,500 bbl. over the output in 1908. The inspection of salt by counties was as follows: Manistee, 2,107,489 bbl.; St. Clair, 1,561,352; Wayne, 1,012,007; Mason, 851,669; Saginaw, 344,729, and Bay, 178,415; a total of 6,055,661 bbl. The entire output was derived from brine wells, and, with the exception of the operation of open pans, the salt was all recovered by the grainer or vacuum processes. The relative importance of these two methods of treatment is indicated by the fact that there are 242 grainers in the 36 blocks of the State, as compared with 28 vacuum pans. In St. Clair and Wayne counties the plants are run with live steam exclusively, the other counties using exhaust steam alone, or in combination with live steam obtained by utilizing the refuse from the saw mills or coal. There were 122 producing brine wells in the State in 1909.

The Detroit Salt Company, of Detroit, opened up a bed of rock salt during the year, which is said to be of good quality, and erected a milling plant with a capacity of 100 tons per hour. The plant of the Butters Salt and Lumber Company, in Mason county, and the Kern mill, in Bay county, were burned during the year. The destruction of these plants, together with the closing of the works of Thompson Bros., the Peninsula Salt Company and the North American Chemical Company for six months, curtailed by a considerable amount what would otherwise have been a greatly increased output.

New York. (By D. H. Newland.)—In 1909 there were two rock-salt mines and about 30 evaporating plants in operation in the State. The output from these sources, including as well the salt contents of brine consumed for soda manufacture, was 9,722,127 bbl., valued at $2,238,939. The total reported for 1908, a relatively poor year in the trade, was 9,005,311 bbl. The production is fixed by the trade requirements which show only a moderate increase from year to year. The capacity of the active mines and plants is largely in excess of the output, and there are many plants now idle that could readily resume operations if conditions warranted. With the marked increase of production in Michigan and the middle west during late years, the New York producers have had to find their markets for the most part locally and in the New England states where they receive incidental protection from the differ-

[1] *Eng. and Mni. Journ.*, LXXXVIII 558-561.

ential freight rates due to shorter haulage. But for this advantage the by-product salt of Michigan would make heavy inroads upon their markets. Foreign salt, from the West Indies and Mediterranean countries, is a strong competitor with the New York product for the trade of the seaboard towns of New England and imports will probably increase in the future, as the Payne tariff reduced the former duty by 20c. a short ton on all grades of salt.

Utah.—The production of salt in Utah was derived entirely by solar evaporation of the waters of Great Salt Lake. The Inland Crystal Salt Company, with a plant about half a mile from Saltair, takes water from the lake through a 15-in. centrifugal pump which delivers it to the first of three salt beds, covering a total area of 1100 acres. The brine is allowed to stand in the first pond until all dirt and sand have settled, during which time the first stages of evaporation are in progress. It is then drawn into the second pond. The natural composition of the lake water is 17 per cent. salt, and when this percentage is brought by evaporation to 26, the solution is saturated, and any further evaporation causes the salt to deposit. The object of the second pond is to bring the evaporation to a point just short of that at which deposition takes place. When this point is reached, the solution is again transferred, this time to the third pond, which is divided into nine sections of twenty acres each, and left until wholly evaporated, when it gives a layer of salt 3 to 5 in. thick.

Any brine which remains unevaporated is run to waste. The salt is then plowed up and wheeled into stacks. The process of refining consists of crushing, drying at a temperature of 200 deg. F. and blowing out dirt and other impurities by means of a centrifugal fan. At the plant of the Salt Air Salt Company, in Salt Lake City, the same principles are applied as at the works of the Inland Crystal Salt Company.

Salt Mining in Foreign Countries.

Australia.—The salt industry of South Australia is one of the most important minor industries of that State. The salt lakes are located in York Peninsula and on Kangaroo Island. The output in 1909 was estimated at 70,000 tons. Over 1000 tons were shipped weekly to the other Australian States and to New Zealand. The domestic unrefined product sold at from $7 to $8 per ton.

Austria.—The production of salt in Austria is a Government monopoly. The large mines at Wieliczka, in Galicia, furnish over one-third of the total production. Up to 1908 the salt in Galicia was mined, but now the easier method of artificially producing brine by introducing water into the mines has been largely adopted. This brine is evaporated in open pans, in vats and by the vacuum process. The value of the salt at the place of production, whether mined or manufactured, ranges from \$2.10 to \$4.50 per metric ton, at which price it is sold by the Government to industrial concerns. This is exclusive of the cost of freight and packing. Other purchasers have to pay the Government tax, which ranges from \$2.40 to \$4 per 100 kg. Large quantities of salt from Galicia and Moravia are sent to Russia under contract.

Canada.—The salt deposits of southwestern Ontario supply the entire Canadian production. In 1909, total sales of 84,037 tons, valued at \$415,219, were reported, as compared with 79,795 tons, valued at \$378,798 in 1908. Stocks on hand at the end of the year were 2671 tons. An idea of the immense deposits of salt in western Ontario may be obtained from the fact that a hole sunk at Goderich, in Huron county, to a depth of 1570 ft., pierced six beds of salt, ranging in thickness from six to 35 ft., whereas at Windsor, in a well 1672 ft. deep, four beds were traversed, one of which was said to be 250 thick. The deposits are exploited by means of brine wells, and the brine evaporated either in vacuum pans or in large open vats. The exports of salt from Canada are insignificant, but imports amount to slightly more than the production.

Ecuador.—There are large deposits of salt in this country at Santa Elena and other points; the production is sufficient to meet the requirements of the country, and a small quantity is exported. The Government has a monopoly of the sale of salt, and its importation is prohibited by law. The production is also restricted to the actual requirements of the people, except that it has been found profitable to export small quantities to neighboring republics. The salt is obtained by solar evaporation in reservoirs from three to six ft. deep and perhaps 60 ft. long by 30 ft. wide. The salt is not refined, but sold in coarse grains, which are pulverized by the consumer a little at a time, as needed.

France.—The most important of the salt industries in France are those in the department of Meurthe-et-Moselle on the eastern border. In this district the deposits of rock salt are in general exploited by brine wells, but in some instances are developed by shafts and mined. The rock salt is of a light gray or red color, and being exceptionally pure, is in demand for the manufacture of soda. The best known sea-salt works is the Peccais plant in Gard, with beds covering an area of 6138 acres and yielding an average of 6.4 to 6.8 tons of salt per acre. The most important works are those of Compagnie des Produits Chimique d'Alais et de la Camargue at the mouth of the Rhone.

The salt works of the French Mediterranean produce only a small amount and are of relatively small importance. In the Southern salt works from 12.1 to 23.7 tons per acre are obtained, while in Corsica the corresponding yield is 68.5 tons. Since 1865 the business of these works has been in the hands of a syndicate. The Western salt works on the coast of the Atlantic extend over a number of departments, but their output does not compare favorably with that of the Southern works, in spite of the advantage they possess in having the sea water raised by the flow of the tide instead of by pumping. The yield of salt per acre in the Atlantic field is about from 0.6 to 11.1 tons per acre. The chief towns for the export of salt are Marseilles and Cette, the port trade being principally with Switzerland, Algiers and Madagascar.

Germany.—In 1909 Germany produced 1,370,668 metric tons of rock salt, and 647,939 tons of evaporated salt derived both from natural and artificial brines. The corresponding productions in 1908 were 1,331,984 and 65,651 tons respectively.

Prussia is the leading salt producer of the empire, and the provinces of Saxony and Hanover yield nine-tenths of Prussia's total output and about one-half of that of the whole of Germany. Outside of Prussia, the other States in order of the amount of salt produced are Wurtemberg, Anhalt, Braunschweig and Alsace-Lorraine. Only about 2 per cent. of the salt consumed is imported, principally from Holland, Great Britain and Portugal. In 1909 imports were 19,509 metric tons, as compared with 24,975 tons in 1908. Exports in 1909 were 365,049 tons, which were distributed as follows: Austria-Hungary, 79,848 tons; Belgium, 60,725 tons; British India, 59,025 tons; Netherlands, 44,522 tons; Sweden, 34,737 tons; Asiastic Russia, 25,316 tons, and Denmark, 20,507 tons.

Germany uses annually about 1,500,000 metric tons of salt, which amounts to about 50 lb. per capita. Practically all the table salt consumed is subject to an internal revenue tax of $25 per metric ton. Exclusive of this tax the wholesale price at which table salt sells varies from $5.15 per metric ton, in localities near the most productive mines to $10.65 in places remote from the source of supply. While much table salt is mined in the Magdeburg district, by far the greater part is produced by evaporation. The vacuum process is practically unknown in Germany, and the brine is generally evaporated by means of steam pipes passing beneath the bottom of open pans or vats.

Italy.—In Italy the salt industry is entirely in the hands of the Government and is utilized as a means of taxation for raising revenue. The importation or production of salt by private individuals is prohibited and it is sold to the public only in special shops. Practically the entire output is derived from sea water evaporated at works on the islands of Sardinia and Sicily, and at Volterra, in the province of Pisa. In 1908 the production from this source was 473,857 metric tons, as compared with 24,033 tons of rock salt, and 15,180 tons recovered from artificial brines. The Government both imports and exports salt. In 1908 the imports were 2610 tons, and the exports 85,489 tons. Of the total exports, 7871 tons were to the United States. For the fiscal year ending June 30, 1909, the receipts from this monopoly were $15,493,934, the expenses, $2,672,269, leaving a net profit to the Government of $12,821,665.

Japan.—Salt has been a government monopoly in Japan since 1904, and no salt can be imported from foreign countries or brought from localities where the salt law is not enforced (leased territory in Manchuria and the Japanese portion of Saghalien, etc.,) except by the Government or with Government permission; nor can it be manufactured by any person or corporation other than those authorized. The State takes the entire output and allows compensation according to quality and locality of the production. The price at which the Government sells the salt is the sum of the amount of compensation paid, plus a fixed profit, ranging from 0.8c. per kin (1.329 lb.) up. Salt for industrial uses is sold at a specially reduced price, and to encourage exportation is sold without the monopoly profit. The annual production (excluding Formosa, Saghalien, etc.,) is approximately 30,000,000 bu., valued at about $5,200,000.

Mexico.—In 1909 the salt deposits at Salinas, in the central part of Mexico, were extensively operated by an English company. The Carmen Island deposits, about 130 miles south of Guaymas, Lower California, were operated throughout the year. While there are several points along the Pacific Coast of Mexico where salt is made from sea water by solar evaporation, the lake on Carmen Island is probably the most important source of this material. The salt is deposited in clear white crystals, which are shoveled by laborers into piles to drain. Tramways transport the dried material to storehouses, where it is sacked for transportation or ground for domestic use. The cost of gathering the salt and transportation to the docks, does not exceed $2 per ton. It was reported that early in 1910 a concession was granted for the exploitation of salt deposits on the west coast of the State of Jalisco. This concession brings the number of those of recognized importance up to three. The largest is located on one of the Tres Marias islands, a short distance off the port of San Blas, in the territory of Tepic. These deposits are controlled by a Mexican syndicate which has California connections for the sale of its output, variously estimated at 30,000 to 40,000 tons per year. There is another deposit, the output from which is about half this amount, at the mouth of the Santiago river, also in the territory of Tepic. The deposit for which a new concession was granted, is said to present opportunities for even a larger output than that at Tres Marias. It is located south of both the older concessions and is not far from Chanela Bay, which should ensure splendid shipping facilities.

Russia.—The total annual production of salt in Russia is about 1,800,000 metric tons. Of this amount over one-half is from natural brine obtained from salt lakes and lagoons, over one-quarter is rock salt and about one-fifth is derived from artificial brine. The chief centers of the lake or lagoon-salt industry are along the coasts of the Black and Caspian seas, more especially in Tauris, Kherson, Astrakhan, and Bessarabia; also in the Don Cossacks, the Urals, the Caucasus, Transcaspia, Russian Turkestan and Siberia. Along the coasts of the Black and Caspian seas there are no less than 300 salt lagoons and salt marshes, among which may be mentioned Lake Elton, 84 square miles in area, and Lake Baskunchak, with an area of 49 square miles. Operations have been suspended at Lake Elton since 1882, due to inadequate transportation facilities, but Lake Baskunchak is connected by a railway with the Volga and yields a good quality of salt. In Siberia the salt industry flourishes in the steppe region of Semipalatinsk, Semiryechemsk, and Akmolinsk, in the southwestern portion of the province of Tomsk, in that of Yakutsk, and in Transbaikalia. In the Semipalatinsk-Semiryechensk area there are 39 salt lakes grouped along the Irtish river. Of these perhaps the most important is Koryakovo Lake, which yields about 30,000 tons of salt annually. As to rock-salt deposits in Siberia, their great distance from market and the absence of convenient means of access are at present the chief obstacles to mining.

The principal centers of rock-salt mining are in the government of Yekaterinoslav, including the district of Bakhmut and Slavyansk, the province of Orenburg, the Caucasus and the Transcaspian region. The government of Yekaterinoslav alone supplies nearly 85 per cent. of the annual output of rock salt in Russia. The Iletskaya-Sachita deposits, where millions of tons of rock salt are in sight, are the only mines that are worked in the government of Orenburg.

The centers of the brine industry are the governments of Perm, Kharkov, Yekaterinoslav, Volagda, Archangel, Warsaw, the Caucasus and Siberia. Russia exports compartively little salt, and most of that to Persia. Imports are about two and one-half times greater than the exports.

Spain.—The production of salt in Spain in 1908 was 822,677 metric tons. The official figures for 1909 are not available, but as the imports decreased from 553,949 tons in 1908 to 545,075 tons, there was probably a small reduction in the 1909 output. Practically the entire production is derived by solar evaporation of sea water. The center of this industry is San Fernando, a small town about six miles from Cadiz. In the district of which this town is the center there are about 150 *salinas* or factories engaged in the manufacture of salt. The method employed is as follows: During the spring tides, sea water is allowed to flow into a large deep reservoir, and thence, as required, is drawn off into another shallower reservoir, in which, through natural evaporation, concentration takes place up to a strength of 18 deg. B. From the second reservoir the liquor is run through winding shallow channels to the crystallizers, each of which usually has superficial area of approximately 500 sq.ft. The crystallizers are shallow, rectangular beds in the earth, and a considerable number is necessary to secure rapid evaporation. According to size, each *salina* possesses 200 to 250 crystallizers. When a sufficient quantity of salt has been deposited, it is collected and brought to the side with wooden shovels, first being washed in the remaining brine to remove all traces of clay. The salt is then laid on dry ground at the side of the crystallizer, and is finally carried away in mats on the backs of donkeys and stacked in the open in huge heaps resembling pyramids. The unit adopted for the sale of salt is the ''last,'' a measure containing about 4730 lb. Each crystallizer in a good season usually produces one and one-half to two lasts. The total cost alongside ship at Cadiz is about 14.85 pesetas per last, of which the Government tax is 1.6 peseta (one peseta equals 17.6c.). This does not cover loss in weight due to the action of rain, etc., which may be reckoned at 10 per cent. per annum. The present selling price is approximately 14.5 pesetas per ''last,'' so that many of the *salinas* are working at a loss, but as the Government tax is imposed even if the factories are not working, the operators prefer to continue production.

United Kingdom.—The production of salt in the United Kingdom in 1909 showed a slight decrease amounting to 1,822,744 long tons, as compared with 1,843,959 tons in 1908. The 1909 output was composed of 209,552 tons of rock salt and 1,613,192 tons of salt from brine. The total exports, including coast shipments, were 822,255 tons; a decline of 27,419 tons from the figures of 1908, the exports to Asia alone showing a decrease of 29,000 tons. Coast shipments declined 4,600 tons. There was an increase, however, of 8,000 tons shipped to the United States and exports to Africa were also greater by 9,000 tons.

Venezuela.—The Government of Venezuela leased a monopoly to the salt business in the country for a period of two years from Dec. 13, 1909, with privilege of two years extension, to the Compañia Nàvegacion Fluvial y Costanera de Venezuela. This gives the company possession of all the present salt works and all the salt deposits of the country. In addition it virtually concedes a monopoly of the coastwise salt transportation during the period mentioned. The company will pay the government a rental of $820,250 for the first year, $868,500 for the second year, $916,750 for the third year, and $965,000 for the fourth year, payable monthly. The manufacture of salt except by the company is prohibited, and even the company is prohibited from importing salt. The contractors agree to dispose of their product at the various salt works or deposits, numbering 14, at prices ranging from 5.75c. to 8.10c. per kilogram. The company is exempt from the payment of federal and municipal taxes, enjoys reduced harbor, dock and railway charges and may import machinery and sacks for its own use without the payment of duty. Should it be necessary for the company to construct piers and portable railways, the Government will bear 40 per cent. of the cost of construction. It is understood that it is the intent of the lessees of the concession to increase the output greatly and to export large quantities of salt.

SILICON.

Ten years ago metallic silicon was a comparatively rare substance and was classed as a laboratory curiosity. By a close study of the science of its manufacture, the Carborundum Company, of Niagara Falls, has placed it among the commercial metals. Its chief use is as a deoxidizer in the refining of steel, and for this purpose it replaces the higher grades of ferro-silicon, aluminum, etc. On account of its greater reducing power, silicon has also replaced aluminum in the manufacture of many low-carbon ferro-alloys, such as ferro-vanadium and ferro-chromium. Although used principally by steel makers, silicon is destined to have a large field when the difficulties of making castings of the metal are overcome. Such castings will find a wide use in the chemical industry as the metal is not attacked by the ordinary acids. Silicon rods for electric resistances have been successfully cast in lengths of 12 in. and up to $\frac{1}{4}$ in. in diameter, but larger castings are porous and crack on cooling. An analysis of the 90-per cent., or most popular, grade of silicon is as follows: Silicon, 90.6 per cent.; iron, 6.7; manganese, 0.08; aluminum, 2.35; phosphorus, 0.02, and carbon, 0.22. The highly objectionable impurity sulphur is entirely absent, and it may be noted that the analysis shows over 2 per cent. of aluminum, which like silicon is a powerful deoxidizing agent.

In 1909 ferro-silicon was manufactured on a large scale in this country by the Electrometallurgical Company with works at Kanawha Falls, W. Va., and Niagara Falls, N. Y., and by the Susquehanna Smelting Company, at Lockport, N. Y. Early in 1910 the latter company decided to close its plant on account of the continued unsatisfactory condition of the ferro-silicon market. In 1909 a Canadian company manufactured ferro-silicon at Welland, Ontario.

SODIUM AND SODA SALTS.

It is now several years since sodium has been an important commercial metal. In The Mineral Industry, Vol. XVI, nine works engaged in its production in Great Britain, Germany, France, and the United States were enumerated. The world's production of sodium in 1907 was estimated at 3500 tons, but other authorities put it as high as 5000 tons. The capacity for production at the end of 1907 was said to be approximately 10,000 tons. For several years the production in the United States, where two companies are engaged in the business, has been approximately 2000 tons per annum, valued at 25c. per pound. We have been unable to obtain any more precise information for 1909. The manufacture of sodium was described and discussed in an exhaustive paper by André Brochet, in *Revue de Chimie Industrielle* for December, 1909.

IMPORTS OF SODIUM NITRATE INTO THE UNITED STATES. (a)
(In tons of 2240 lb.)

Year.	Quantity.	Value.	Value per ton.	Year.	Quantity.	Value.	Value per ton.
1900..........	182,108	$4,935,520	$27.10	1905..........	321,231	$11,206,548	$34.89
1901..........	208,679	5,999,098	28.75	1906..........	372,222	14,115,206	37.92
1902..........	205,245	5,996,205	29.21	1907..........	364,610	14,844,675	40.71
1903..........	272,947	8,700,806	31.88	1908..........	310,713	11,385,393	36.64
1904..........	228,012	9,333,613	40.93	1909..........	422,593	13,281,629	31.43

(a) As reported by the Bureau of Statistics, Department of Commerce and Labor. The figures of value appear to be doubtful, especially with respect to the earlier years.

NITRATE OF SODA STATISTICS. (a)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at close of year.
1899................	1,373,000	1,140,000	160,000	1,330,000	236,000	741,000
1900................	1,429,000	1,126,000	175,000	1,324,000	221,000	794,000
1901................	1,238,000	1,154,000	192,000	1,364,000	243,000	617,000
1902................	1,360,000	1,028,000	214,000	1,259,000	263,000	660,000
1903................	1,435,000	1,127,000	265,000	1,412,000	155,000	654,000
1904................	1,476,000	1,131,000	275,000	1,447,000	162,000	672,000
1905................	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906................	1,700,000	1,243,000	355,000	1,636,000	190,000	733,000
1907................	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908................	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909................	2,085,000	1,465,000	398,000	1,929,000	337,000	999,000

(a) Statistics of W. Montgomery & Co., London.

Nitrate of Soda.

The production of this important substance continues to be derived chiefly from Chile, all other sources being relatively insignificant. The statistics of production, consumption, etc., are given in the preceding table. There has lately been published a treatise comprising an exhaustive review and history of the niter industry of Chile, by Semper and Michels. This was summarized in an article by Mark R. Lamb, published in the *Eng. and Min. Journ.*, of July 2, 1910.

Other Soda Salts.

The discovery of large deposits of soda at Lake Magadi, the terminal point of the projected line of the Uganda railway, Central Africa, was reported by F. Shelford, an English engineer. It is thought that the deposits are of commercial value, and a concession to work them has been granted to M. Samuel & Co. by the East African Syndicate. Mr. Shelford describes the deposits as occurring in a lake about 10 miles long by two or three miles wide, looking like an ordinary sheet of water of somewhat reddish hue. Near the shore it was found that the water was only a few inches deep and covered a hard surface looking like pink marble, which was in fact a deposit of soda. Some borings were made, showing the deposit to be of considerable depth.

IMPORTS OF SODIUM SALTS. (*a*)
(In tons of 2000 lb.)

	1905		1906		1907		1908		1909	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Arseniate......	25.5	$ 1,745	79.9	$ 5,902	84.2	$ 9,306	159.1	$ 13,922	125.4	$ 7,108
Ash...........	9,012	167,088	5,103	98,714	3,373	73,052	1,979	41,607	2,220	48,674
Bicarbonate....	173.3	6,858	159.9	6,075	68	4,274	42.6	2,555	60.9	4,821
Bichromate and Chromate.....	56.7	5,449	6.6	584	3.5	425	54.0	4,304	1,206	97,661
Caustic.........	636	35,294	671	36,841	642	39,396	566	31,716	391	24,742
Carbonate (Crystal).....	219	6,350	111	3,045	63	2,026	30	1,937	84	3,464
Chlorate.......	143	12,309	58	7,032	642	39,396	....	....	....	12
Chloride (Salt)..	163,203	506,198	163,683	488,898	155,318	474,833	168,686	471,476	145,678	437,892
Hyposulphite...	502	10,436	137	2,858	35	1,093	6	448	6	312
Nitrate........	282,692	9,557,522	373,988	13,118,214	342,086	14,041,346	329,605	12,547,611	353,558	12,583,417
Nitrite.........	314	29,590	429	40,751	389	37,623	100	10,015	76	7,258
Phosphate.....	40	1,462	65	2,428	14	855	13	619	25	707
Prussiate......	905	125,230	884	118,153	1,074	175,674	857	129,082	981	123,880
Sal Soda.......	1,484	18,470	498	7,381	380	4,771	249	3,419	252	3,231
Salt Cake......	1,382	15,738	1,808	15,997	3,044	37,044	208	2,169	18	767
Silicate........	552	13,434	681	13,504	618	11,461	744	13,376	509	8,578
Sulphide.......	359	10,339	1,024	29,835	723	20,988	300	9,539	267	7,764
Sulphite.......	29	1,168	78	2,851	12	803	58.5	3,259	235.4	10,150

(*a*) For fiscal years ending June 30. From the *Oil, Paint and Drug Reporter* Feb. 21, 1910.

The Market for Soda Salts in the United States.

During 1909 there was a steady demand for caustic soda, consumption in the textile, glass, soap and paper industries showing improvement. The price remained steady at $1.75@1.80 for 60-per cent. The consumption of bicarbonate of soda was large. The price remained steady at 1c. per pound. Great improvement in industrial conditions was reflected also in the demand for soda ash, the glass and paper makers having made large withdrawals under contract, while at times inquiries were urgent in character. The greatest activity occurred during the autumn. At this time the general demand for consumption reduced available supplies to a low level, and the market displayed a very firm tone, although the price remained quotably unchanged. The market at the end of the year was the same as at the beginning, 58-per cent. in bags being quoted at 77c. in car lots.

SULPHUR AND PYRITES.

By John Tyssowski.

The production of sulphur in the United States in 1909 was slightly below that for 1908. This was due to a reduction of the stock on hand held by the principal American producers. Contract deliveries to the powder, paper, rubber and other large consuming industries were heavy and supplies at the distributing points were kept down. As a consequence, the 1909 output is probably nearer the actual consumption than was the case in previous years when large stocks were piled up. Car shortage during the summer months caused more or less difficulty to consumers, but the inconvenience proved to be merely temporary.

CONSUMPTION OF SULPHUR IN THE UNITED STATES.
(In tons of 2240 lb.)

Source.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Sulphur—Domestic production	7,443	35,098	193,492	215,000	294,000	307,806	307,761	303,000
Imports	176,951	190,931	130,421	84,579	64,646	20,318	20,118	26,914
Total	184,394	226,029	323,913	299,579	358,646	328,124	327,879	329,914
Exports	1,253	967	2,493	1,713	14,419	35,925	27,894	37,142
Consumption	183,141	225,062	321,420	297,866	344,227	292,199	299,985	292,772
(a) Sulphur contents	179,478	220,560	314,992	291,909	337,342	286,355	293,985	286,906
Pyrites—Domestic production	228,198	199,387	173,221	224,980	225,045	261,871	206,471	210,000
Imports	440,363	427,319	413,585	515,722	533,346	627,985	668,115	692,385
Total	668,561	626,706	586,806	740,702	758,391	889,856	874,587	902,385
Exports	3,060	1,330	....	....	....	....	....	....
Consumption	665,501	625,376	586,806	740,702	758,391	889,856	874,587	902,385
(b) Sulphur in domestic	104,071	87,730	76,217	98,991	99,020	115,223	90,847	92,400
(c) Sulphur in foreign	205,532	200,215	194,385	242,389	250,673	295,153	314,015	325,420
Total sulphur content	309,603	287,945	270,602	341,380	349,693	410,376	404,862	417,820
Grand total sulphur consumption	489,081	508,505	585,594	633,289	687,035	(d) 696,731	(d) 698,847	704,768

(a) Includes crude and refined sulphur. Sulphur content of crude is computed at 98 per cent. (b) Computed at 44 per cent. (c) Computed at 47 per cent. (d) This figure is in excess of the true consumption as a large percentage of the domestic output of sulphur was stored.

Trade returns for 1909 show that the total imports of sulphur were 26,914 tons and exports 37,142 tons, an excess of exports amounting to 10,228 tons. Japan furnished 16,719 tons of the amount imported in 1909. For 1908, imports were 20,118 tons, exports 27,894 tons, or an excess of 7776 tons exported. Although this indicates that we again produced more sulphur than was necessary for our own consumption the excess was not as large as might be expected from the natural increase of the industry.

Market Conditions and Prices.—There was no variation of market prices during 1909, and although there was considerable change in governing conditions of the foreign market there was no development of sufficient importance to affect domestic quotations. Prices remained constant throughout 1909 at $22 per long ton at New York for prime Louisiana sulphur, and $22.50 at Boston, Philadelphia and Baltimore. Quotations on roll sulphur were firm at $1.85@2.15 per 100 lb.; $2@2.40 for flour; $2.20@2.60 for flowers sublimed. The Sicilian brimstone was held at the same figures but could not compete successfully with the American producer at even prices on account of the importer not being able to offer the same facilities to the consumer as do the American makers, and also due to the natural preference for home produce.

IMPORTS OF SULPHUR INTO THE UNITED STATES.
(In tons of 2240 lb.)

Kind.	1906.		1907.		1908.		1909.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
Crude..........	72,603	$1,282,873	20,399	$355,944	19,620	$318,577	28,799	$492,962
Flowers........	1,099	29,565	1,458	41,216	793	22,562	770	23,084
Refined........	709	17,928	606	14,589	692	17,227	966	26,021
Precipitated....	28	3,224	60	8,426	30	4,012	58	7,565
Total........	74,439	$1,333,590	22,523	$420,175	21,135	$362,378	31,093	$549,632

WORLD'S PRODUCTION OF SULPHUR. (*a*)
(In metric tons.)

Year.	Austria. (*b*) (*e*)	Chile.	France. (*b*)	Germany	Greece.	Italy. (*b*)	Japan.	Spain.	United States.	Total.
1895..........	932	....	4,213	2,061	1,480	370,766	15,557	2,231	1,676	398,916
1896..........	781	940	9,720	2,263	1,540	426,353	12,540	1,800	3,861	459,798
1897..........	642	664	10,723	2,317	358	496,658	12,013	(*b*)3,500	1,717	528,592
1898..........	589	1,256	9,818	1,954	135	502,351	10,339	3,100	2,770	532,312
1899..........	671	989	11,744	1,663	1,150	563,697	10,241	1,100	1,590	592,290
1900..........	985	2,472	11,551	1,445	891	544,119	14,439	750	4,630	581,282
1901..........	5,048	2,516	6,836	963	2,336	563,096	16,548	610	6,977	604,930
1902..........	3,826	2,636	8,021	487	1,391	510,333	18,287	450	7,565	552,996
1903..........	4,610	3,560	7,375	219	1,266	553,751	22,914	1,680	35,660	631,035
1904..........	6,431	3,594	5,447	209	1,225	527,563	25,587	605	196,588	767,249
1905..........	8,542	3,470	4.637	205	1,126	568,927	24,652	610	218,440	830,609
1906..........	15,258	4,598	2,713	178	(*d*)1,000	499,814	27,589	700	298,704	845,956
1907..........	24,199	2,905	2,000	176	(*d*)1,000	426,972	33,329	3,612	312,731	801,911
1908..........	17,429	2,705	2,189	811	(*d*)1,000	445,312	33,419	13,872	312,700	829,437
1909..........	(*c*)	4,508	(*c*)	1,185	(*c*)	(*c*)	35,480	(*c*)	303,000	(*b*)

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary.

Sulphur Mining in the United States.

California.—It was reported that in the latter part of 1909 the San Francisco Sulphur Company examined the old Supan deposit on the west slope of Mt. Lassen, 55 miles from Red Bluff, Tehama county, and about five miles from Morgan Spring. This deposit was discovered over

30 years ago by Dr. Milton Supan and a road was built to it but no production was ever recorded. The Deer Creek survey for the Goose Lake Southern railroad passes within eight miles of the deposit. The quality of the sulphur is reported to be good, but the expense of getting it to the market has heretofore prevented the working of the deposit.

Louisiana.—As usual Louisiana furnished the bulk of the American production of sulphur, the Union Sulphur Company being the principal operator. Early in 1909 the discovery of another big deposit of sulphur was reported to have been made by the Meathers Oil Company in drilling a well on the Eddy & Gunn rice farm about six miles north of Sulphur in Calcasieu county. If this discovery is authenticated it will mean that the deposits heretofore so extensively exploited and developed by the Union Sulphur Company underlie a much larger area than has generally been supposed.

Nevada.—The Rabbit Hole or Humboldt sulphur deposit is said to cover a large area of territory and to contain an immense supply of this mineral. The sulphur as taken from the ground is stated to be almost pure and to require only the crudest kind of refining. In 1909 about 500 tons of sulphur were produced in Nevada.

Texas.—In several localities explorations have been carried on recently, mostly in connection with the sulphur deposits disclosed in the oil-drilling operations. The most important deposit so far developed is at Bryan Heights, Brazoria county. This has been partly proved and is now in negotiation. Other sulphur operations have been under way near Matagorda and at Liberty. So far there has been no production from any of these operations. A drill hole near Toyah in western Texas is reported to have penetrated an extensive deep sulphur deposit. The small operations in eastern El Paso county, on the solfataric deposits have been suspended, owing chiefly to the high cost of fuel for treatment.

Wyoming.—The exploitation of the deposit near Thermopolis was steadily pushed by the Wyoming Sulphur Company.

Geology of the Sulphur Deposits of Louisiana and Texas.

By Kirby Thomas.

The notable sulphur deposit in Calcasieu parish, Louisiana, operated by the Union Sulphur Company, and deposits at Bryan Heights, Brazoria county, Texas, and at several other points in the Gulf coastal-plain region are unique geologically. They are all definitely related to the so-called "dome" formations. These "domes," usually indicated by distinctive and characteristic elevations in the level plains of the region, have been found by the drilling, which has been carried on extensively in all parts of the area, chiefly in prospecting for oil, to be cones or craters of limestone in the sedimentary formation of the region. They rise from more than 2000 feet deep and sometimes come to the surface. When they terminate below the surface they are usually indicated by a slight elevation which gives the designation. These craters are of limited extent—from a few acres to a few hundred acres and inside the walls are deposits of gypsum, sulphur and rock salt, the first two minerals being generally mixed irregularly with much broken limestone and the salt being massive and at the bottom extending to unknown depths. Over the craters is a more or less horizontal bed of limestone presumably lifted up from great depths by the process of the formation of these deposits, the force being from the crystallization of the minerals from the solution. These domes sometimes afford suitable receptacles for oil and the Gulf oilfields as at Spindle Top, Beaumont, etc., are all connected directly with these dome formations. If the dome structure has been raised above the surface, the rock, gypsum and sulphur are eroded and surface rock-salt deposits result as at Belle Island, La. Most of the submerged domes contain gypsum and sulphur in varying quantities, usually in the upper parts.

These dome formations have their origin in deposition from solutions of deep-seated origin in chimneys and passages at the intersection of fault planes in the deep strata.

This explanation of the genesis of these deposits has a practical bearing as it presumes the limiting of the sulphur deposits to these domes and within the individually small area usually occupied by them. Also as most of the known domes in the region have been drilled for oil, the possibility of finding other similar deposits is minimized. The theory of the Texas-Louisiana sulphur deposits was first announced by Lee Hagar in the *Eng. and Min. Journ.*, July 28 and August 4, 1904. Later it has been modified and more fully worked out by G. D. Harris in *Bull.* No. 7 (1908), of the Louisiana Geological Survey. A supplemental article by Mr. Harris was published in *Economic Geology*, Jan.-Feb., 1909, under the title, "The Geological Occurrence of Rock Salt in Louisiana and Texas." In western Texas in El Paso county are several small deposits of sulphur of solfataric origin.

Sulphur in Foreign Countries.

Japan.—The yearly production of sulphur in Japan amounts to about 33,000 metric tons. In 1909 Japan exported 17,022 metric tons to the United States, 16,100 to Australia and about 2720 metric tons to Switzerland. A large portion of this is simply congealed from the hot sulphur springs in the volcanic regions of the country, particularly on the island of Kyushu. This sulphur is usually 99.8 per cent. pure and is hence classed by the United States Customs officials as refined sulphur and is accordingly subject to a duty of $4 per ton. The sulphur mined in Hokkaido in a solid state is simply subjected to melting in large boilers and sorted into several grades. It is admitted to the United States duty free.

Mexico. (By Kirby Thomas.)—Numerous native sulphur deposits are found in Mexico. The most talked of, that in the crater of Popocatepetl, was energetically heralded a few years ago, but investigation has been adverse to the commercial operation of the deposit, the magnitude of which has been exaggerated. At Los Cerritos, San Luis Potosi, a property belonging to the Virginia-Carolina Chemical Company has, for more than a year, been operated extensively, the product being shipped to Germany. A deposit at Los Conejos, Durango, near Torreon, is controlled by a local company and is operated to supply the demand for the powder factory at Dynamita and for industrial purposes in Mexico City. The Mexican price for the product is from 60 to 90 pesos per metric ton. In Tamaulipas is an undeveloped deposit of magnitude. In Baja, California, are two promising deposits, El Promentorio and Los Virgines, both now under option to Philadelphia interests.

Russia.—In Kyrk-Tschulva in the Transcaspian district of Aschabad near Schjich deposits rich in sulphur are reported. These deposits are stated to form hills often 125 ft. high and a couple of miles in circumference. The ores on the surface contain from 38 to 62 per cent. sulphur and it is estimated that the region contains several hundred million poods of the ore. Previous attempts to work these deposits have been unsuccessful because of the improper methods employed. Practically all of these deposits are claimed to have been bought up by a company under the name of "Sulfur," which intends to exploit them in a thorough manner.

Sicily.—Figures supplied by Parsons & Petit, American agents for the Consorzio, show that stocks on hand in Sicilian ports at the end of 1909 were as follows: Girgenti, 423,491 metric tons; Licata, 157,592; Catania, 55,893; Termini, 3081; Palermo, 352; total, 640,409. This is an increase of 25,543 metric tons over the stock on hand at the end of 1908. It is interesting to note that Girgenti was the only port which showed an increase of stocks during the year, a slight reduction being made at each of the other ports named. The exports for the year were, as shown in the accompanying table, 26,444 metric tons, a decrease of 2281 metric tons from the 1908 figure. The exports to the United

States and Canada during 1909 showed an increase of 7485 tons over that for 1908. (In 1909 the exports were 19,491 metric tons.)

The appointment of a new commissioner to replace the former one and the governing council of the Consorzio has apparently benefited that organization to a great extent. The Consorzio has for a long time been a failure as a money-making enterprise, but since the change in the executive, prices have been held steady, production has been regulated in accordance with consumption and the sulphur business of Italy rests upon a healthier basis than for years.

The French Chamber of Deputies has imposed an import tax on all sulphur analyzing over 98 per cent. This excludes from the classification "crude" all sulphur above this figure, and it is evident that this blow is aimed at the Louisiana product; probably to the advantage of the Sicilian.

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1900-1907. (a)
(In tons of 1000 kg.)

Country.	1902.	1903.	1904.	1905.	1906.	1907.	1908. (d)	1909. (d)
Austria	19,086	17,926	23,374	25,111	22,756	24,597	32,501	24,820
Belgium	12,323	15,233	13,627	14,442	13,940	8,853	11,410	16,536
France	67,249	74,372	103,040	96,170	67,536	59,725	93,829	87,831
Germany	25,906	32,553	31,613	28,319	34,967	37,100	30,399	28,788
Greece and Turkey	20,548	22,133	25,376	25,069	26,560	27,608	27,810	21,131
Holland	8,648	5,157	8,122	4,425	5,539	11,379	8,775	7,184
Italy	45,603	45,572	79,619	99,633	79,519	58,926	60,551	50,602
Portugal	10,614	14,064	8,373	13,196	12,302	12,778	12,294	14,797
Spain	2,249	4,099	4,064	2,478	3,120		6,125	5,928
Scandinavia (c)	24,918	28,292	20,120	18,288	21,608	25,155	27,209	18,703
Russia	17,295	15,068	15,141	16,673	16,181	15,210	19,960	19,366
United Kingdom	25,477	19,210	18,108	18,847	20,883	16,561	20,119	19,374
United States	168,919	155,996	100,000	70,332	41,283	9,476	12,006(e)	19,491 (e)
Other countries (b)	18,484	25,833	25,167	23,277	21,238	26,646	13,078	24,368
Totals	467,319	475,508	475,745	456,260	387.432	334,014	376,066	358,919
Stock in Sicily, Dec. 31.	339,113	361,220	396,541	462,437	525,115	576,377	614,866	640,409

(a) In 1900 and 1901 by A. S. Malcolmson, New York; for following years, by Emil Fog & Sons, Messina. (b) Mainly South Africa, Northern Africa, Asia, Australia and the East Indies. (c) Including Norway, Sweden and Denmark. (d) Reported by Parsons & Petit, New York. (e) Includes Canada.

Guiseppe Oddo is still working for the relief of the Sicilian sulphur industry. His latest proposal is to market a product, with a uniform content of 50 per cent. sulphur, to compete against pyrites in the market for raw material for the manufacture of sulphuric acid. In brief, his proposal is to utilize the *sterro,* or fines mixed with low-grade sulphur, of which there is at present about 650,000 tons lying unsold in Sicilian ports, in the form of a conglomerate. The cost of making this conglomerate is said not to exceed 4d. a ton. The cost of a ton of chamber acid from pyrites is stated by Mr. Oddo as 27s. 6d., of which 14s. is for pyrites and niter, and 6s. for interest and depreciation. By adopting the use of the conglomerate it is claimed that a quarter of the latter sum would be saved, because the capacity of the plant would be increased. The cost of labor per ton of acid, exclusive of repairs, is taken as 2s. in ordinary practice, and it is also claimed that half of this could be saved. Considering also the saving in fuels and repairs, the total advantage gained through the use of the conglomerate is claimed to be 3s. 7d. per ton of chamber acid, or 6s. per ton of pyrites or conglomerate burned. Mr. Oddo, therefore, claims that for equal sulphur content his material is worth 6s. per ton more than pyrites, and that, since it can be produced at a price only 3s. in advance of that of 50-per cent, pyrites, it possesses advantage sufficient to attract even conservative manufacturers to a new material.

Spain.—A recent report by the Spanish Inspector General of Mines on the petroleum and sulphur beds of Cadiz contains interesting information on the Arcos sulphur mines. It is stated that 29 soundings were taken in this district during the last two years and investigations of the extent of the sulphur-bearing zone are still being carried on. At 65 meters the maximum depth attained, water charged with hydrogen sulphide was encountered. Iron pyrites were also found to occur in the same district. In the Tertiary deposits, sulphur formed 17 per cent. of the whole, varying from 4 per cent. at the borders of an excavation, to 40 per cent. in some portions. The ground is stated to be impregnated by the sulphur up to the recently formed earth which covers the Tertiary deposits. The Tertiary deposit as shown by a boring near Salado, is only nine meters thick.

Pyrites.

The pyrites mining industry thrived during 1909, and although few new companies reached the producing stage, the established ones, almost without exception, showed a tendency toward improving their methods and equipment; a sure sign of the healthy condition of the business.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITES IN THE UNITED STATES. (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1897	133,368	$404,699	259,546	$847,419	392,914	$1,252,118
1898	191,160	589,329	171,879	544,165	363,039	1,133,494
1899	178,408	583,323	310,008	1,074,855	488,416	1,658,178
1900	201,317	684,478	322,484	1,055,121	523,801	1,739,599
1901	234,825	1,024,449	403,706	1,415,149	638,531	2,439,598
1902	228,198	971,796	440,363	1,650,852	668,561	1,622,648
1903	199,387	787,579	425,989	1,628,600	625,376	2,416,179
1904	173,221	669,124	413,585	1,533,564	586,806	2,202,688
1905	224,980	752,936	515,722	1,780,800	740,702	2,533,736
1906	225,045	767,866	597,347	2,138,746	822,392	2,906,612
1907	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908	206.471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452

(a) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (b) Net imports, less re-exports of 3060 tons in 1902 and 1330 tons in 1903.

The production of pyrites in 1909 in the United States was only slightly larger than in 1908, but this is due to the fact that stocks were generally carried over from 1908, rather than to a lack of demand in 1909.

The scare over the Ducktown acid production about subsided, for, although the Tennessee Copper Company operated one 400-ton unit of its acid plant throughout the year, and is now constructing another unit of equal or greater capacity, and the Ducktown Sulphur, Copper and Iron Company operated its 180-ton plant after the latter part of June, no noticeable curtailment in the market for pyrites resulted. The reported failure of the attempt to organize the new fertilizer combine possibly accounted in part for this. The fact that acid plants (notably at Charleston, S. C.), have recently been able to market their pyrites-cinder residue to iron smelters no doubt has been of considerable help to them.

Conditions about the Great Lakes were practically unchanged in 1909, as the Canadian companies which were expected to compete actively for this trade did not enter the field on any scale.

WORLD'S PRODUCTION OF PYRITES.
(In metric tons.)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Hungary.	Italy. (*a*)
1896	2,560	.....	30,580	10,177	282,064	129,168	52,697	45,728
1897	1,828	.....	35,291	10,752	303,488	133,302	44,454	58,320
1898	147	3,670	29,223	12,302	310,972	136,849	58,079	67,191
1899	283	.....	25,112	12,426	318,832	144,623	79,519	76,538
1900	400	1,700	36,308	12,484	305,073	169,447	87,000	71,616
1901	560	4,570	31,982	10,405	307,447	157,433	93,907	89,376
1902	710	5,170	32,304	9,315	318,235	165,225	106,490	93,177
1903	720	6,589	30,822	9,794	322,118	170,867	96,619	101,455
1904	1,075	10,421	29,980	10,452	271,544	174,782	97,148	112,004
1905	976	19,045	29,713	12,381	267,114	185,368	106,848	117,667
1906	908	13,474	35,927	11,318	265,261	196,971	112,623	122,364
1907	397	3,671	35,494	10,357	283,000	196,320	99,503	126,925
1908	357	5,000	42,934	9,599	284,717	219,455	95,824	131,721
1909	(*b*)	(*b*)	51,744	8,564	(*b*)	198,688	(*b*)	(*b*)

Year.	Japan.	Newfound-land	Norway. (*c*)	Portugal. (*c*)	Russia.	Spain.	Sweden.	United States.	Total.
1896	(*b*)	27,267	60,507	207,440	11,550	100,000	1,009	111,031	1,071,778
1897	7,626	32,790	94,484	276,738	19,380	100,000	517	133,502	1,252,472
1898	8,726	32,335	89,763	302,686	24,570	70,265	386	194,219	1,341,383
1899	8,376	26,154	95,636	347,234	23,250	107,386	150	181,263	1,446,782
1900	16,166	*Nil*	98,945	402,870	23,154	34,638	179	204,538	1,464,512
1901	17,589	7,532	101,894	443,397	30,732	33,953	*Nil*	238,582	1,568,999
1902	18,580	26,000	121,247	413,714	26,465	145,173	*Nil*	231,849	1,713,654
1903	16,149	42,674	129,939	376,177	22,780	155,739	7,793	202,577	1,692,812
1904	24,886	61,166	133 603	383,581	31,667	161,841	15,957	175,992	1,696,099
1905	25,569	51,534	162,012	352,479	30,689	179,079	20,762	228,580	1,789,816
1906	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907	56,166	28,000	236,038	365,164	18,316	225,830	27,000	266,061	1,978,242
1908	33,867	(*b*)	269,129	105,939	56,345	263,457	29,569	209,774	(*d*)1,757,687
1909	27,066	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	16,104	213,371	....

(*a*) Cupriferous in part. (*b*) Reports not yet available. (*c*) Both iron and copper pyrites. (*d*) Not including Newfoundland. (*e*) Estimated.

Market Conditions and Prices.—Prices exhibited little range throughout the year, being practically stationary at $11\frac{1}{4}$c. per unit per long ton for non-arsenical furnace, f.o.b. mines, and 10@$10\frac{1}{4}$c. for the domestic fines. The imported pyrites fetched 12@$12\frac{1}{2}$c. per unit for the non-arsenical furnace, ex-ship New York, 12@$11\frac{3}{4}$c. for the arsenical furnace, $10\frac{3}{4}$c. for the non-arsenical fines and $8\frac{3}{4}$@9c. for arsenical fines. These are practically the prices which prevailed during 1908, but early in 1909 the prices were shaded to quite an extent, foreign fines being reported as offered at Atlantic and Gulf ports as low as 8c. ex-ship. The Government trade returns show that during 1909, 692,385 tons of pyrites were imported into the United States, as against 668,115 tons during 1908.

Pyrites Mining in the United States.

As will be noted, a number of the large American companies took advantage of the slackness of trade in the early part of 1909 resulting from stocks carried over, and spent a great deal of time in developing additional ore reserves and refitting their mills.

The southern properties showed a general tendency to better mill operations, but the lack of engineering methods in underground work is still to be criticized.

Massachusetts.—The Davis mine near Charlemont, showed a restricted output on account of a rather disastrous cave-in which occurred in the early part of 1909. At the north end of the property a new shaft, No. 4, was sunk about 90 ft., but neither the main nor No. 3 shafts were in commission. The difficulties are now reported to be overcome and the normal output is looked for in 1910. The company recently experimented with motor trucks and expects in the near future to substitute these for the wagon teams which are now used to haul the output of the mine to the railroad. At Charlemont station on the Boston & Maine Railroad, the Mount Peake mine was actively operated and produced a small tonnage of ore. Most of the work carried on was, however, of a development character. This mine still yielded some chalcopyrite ore associated with the pyrite. The State produced only about 11,000 tons of pyrites in 1909.

New Hampshire.—The Milan Mining and Milling Company's property, situated about 12 miles from Berlin, was the largest producer for the year. The total output in the State, however, amounted to only about 5000 tons, or about one-third of that for 1908.

New York.—The St. Lawrence Pyrites Company produced as usual large tonnages of low-grade ore from its Stella and Anna mines. The total output in the State was larger than in 1908, amounting to about 35,000 tons.

Georgia.—At Villa Rica, Carroll county, the Sulphur Mining and Railroad Company worked its pyrites mines regularly during 1909. Improvements were instituted in the mill. At several other points in Georgia, notably in Cherokee county promising prospects were opened.

Virginia.—This State continued to lead as a producer of pyrites. The total production was about 120,000 tons, including pyrrhotite used for making acid. The larger mines in the mineral belt of Louisa and Prince William counties, with the exception of the Boyd-Smith at Mineral, Louisa county, were regular producers in 1909, but the total production was somewhat curtailed by reason of improvements instituted. Both the Arminius and Sulphur mines at Mineral were engaged in sinking new shafts to further develop their properties, and the latter is expected to enlarge its mill capacity during the ensuing year. As usual these mines produced mostly fines. The Cabin Branch mine, at Dumfries, Prince William county, began operating its new mill in September. Early in the year this company moved its 40-ton smeltery from the mine to Barrows Siding, about six miles distant on the main line of the Washington Southern Railway. The furnace was run on selected chalcopyrite ore for a short while.

In southwestern Virginia near Chestnut Yard, Carroll county, the Pulaski Mining Company was engaged in developing an immense pyrrhotite orebody by open cut, and also in prospecting with churn drills. This orebody, known as the "Great Gossan Lead," strikes southwest through Floyd, Carroll and Grayson counties for a distance of about 20 miles. The width varies up to a hundred feet or so, the orebody dipping about 45 deg. to the northeast. The company's acid plant at Pulaski operated throughout the year on this ore. The capacity of the plant is about 300 tons crude ore per day. The iron cinder produced is treated in nearby iron-blast furnaces.

Pyrites Mining in Foreign Countries.

Canada.—The Northern Pyrites Company, which was expected to become an important factor in this trade, did not actively enter the field. The production in 1909 only amounted to about 5000 tons. This property, known as the Vermilion pyrites mine, is situated on Vermilion lake, in western Ontario, about 2½ miles by aerial tram from the branch line of the Grand Trunk-Pacific Railway from Fort William, Ont. The orebody is large and the pyrites of almost a theoretically pure composition. The property changed owners about the end of 1909 and will be extensively developed during 1910.

The Northland mine, formerly known as the Harris or Rib Lake, shipped lump ore to the markets of eastern Canada and the United States in 1909. The main shaft on the property (situated near Rib lake in the Temagami forest reserve about one-half mile from the Temiskaming & Northern Ontario Railroad) was sunk about 300 feet.

Mexico.—Two somewhat similar deposits of pyrites in the Campo Morado range, of the district of Aldama, Guerrero, are described by Luis Hijar Haro. The mines are controlled by the Reforma Mining and Milling Company and the Compañia Explotadora. The Reforma property is situated about 60 km. southwest of Teloloapan at an altitude of 1480 m. The region is in the last spurs of the Sierra Nevada, and is composed of sedimentary rocks of Archean or possibly of Paleozoic age and Cretaceous rocks. The beds strike from north to south, with a usual dip to the west. The schists vary in color and texture, being black and carbonaceous, and contain finely laminated veins of quartz and calcite. On the west of the Sierra are some eruptive dikes.

The Reforma deposit occurs near one of the highest peaks and in relation to the dioritic dike, which forms the actual summit of the Sierra. The deposit is composed of an enormous prism of pyrites lying between black altered schist or slate, and dioritic conglomerate, which rocks form the floor and roof respectively. The beds of slate are conformable to the prism in its immediate vicinity. The explorations reach a depth of 250 m., measured from the vertex of the prism.

There is shown to be an oxidized band about the deposit having the following average composition: Iron (Fe_2O_3), 30 per cent.; silica, 32; lead, 10 to 20 ($PbCO_3$ and $PbSO_4$); lime 2; barytes, 2. It is estimated that the oxidized zone represents a volume of 30,000 cu.m. The average composition of the mineral in the interior of the prism is somewhat as follows: Iron, 38 per cent.; sulphur, 45; silica, 5; lead, 2; copper, 2. The ore contains some gold and silver. The ores resemble those found at Mt. Lyell, Tasmania; Rio Tinto, Huelva, Spain; and Iron Mountain, Shasta county, Cal. They are amenable to pyritic smelting on a large scale.

Russia.—The erection of a large sulphuric-acid plant in the Neivo Rudyansk factory of the Verch-Isset district is reported to have been started in 1909; the plant designed to produce 250,000 poods of sulphuric acid per year by the contact process. It is stated that pyrites from the Kalatinsk mine will at first be used but later auriferous pyrites from the Bynarski mine which lies about 6 versts from Neivo Rudyansk will be utilized.

Spain.—The production of pyrites (*minerai de soufre*) at Rio Tinto in 1909 was 569,604 metric tons, or 98,873 tons less than in 1908. In addition, 1,788,987 metric tons classed as copper ore were produced, of which 1,184,688 tons were treated locally. The Rio Tinto ores are not classed as pyrites in the Spanish government reports.

Technology.

Improvement of Milling Methods.—The tendency toward improved milling methods in American operations was marked in 1909, much attention having been paid to this technical feature of the industry. At Milan picking was installed on two 24-in. Jeffrey belts. Shaking screens, a Richards classifier and Wilfley and Bartlett tables were used. No changes were introduced in the concentrating method at Davis, jigging still being conducted in a four-compartment Harz jig. The plant, however, was somewhat enlarged. At the St. Lawrence Company's mill Hancock jigs replaced the Harz formerly used. The Cabin Branch mine at Dumfries, Va., built a new mill comprising crushers, picking tables, Sturtevant rolls and Harz jigs.

At the Mineral, Va., mine of the Sulphur Mining and Railroad Company an interesting development in pyrites concentration was instituted in the removal of iron impurities by magnetic concentration. The jigged material is run over a Cranberry magnet which removes particles of iron oxide and pyrrhotite, thus raising the sulphur contents of the finished product 4 or 5 per cent. Balancing the increased loss of sulphur against the saving effected in freight charges, shows that the operation gives a commercial saving. This company also put in Harz jigs and made other changes at its mill at Villa Rica, Ga. All of these improvements indicate that the producers of pyrites realized that improved methods were necessary to the success of their business.

Bibliography.

Fay, A. H. "Pyrite Mining in New Hampshire by Milan Mining and Milling Company." (*Eng. and Min. Journ.*, Sept. 4, 1909; 1 p.)

Hijar y Haro, Luis. "The Pyrites Deposit of Campo Morado, Guerrero, Mexico." (*Min. Journ.*, Oct. 9, 1909, ¾ p.)

Lawton, N. O. "Makushin Sulphur Deposits, Unalaska." (*Min. and Sci. Press*, Feb. 13, 1909; 2 pp.)

Monticolo, A. "Nuove proposte pel Trattamento del Minerale Solfifero." (*Rassegna Mineraria*, Oct. 21, 1909; 2½ pp.)

Oddo, G. "Solfimetro per la Determinanizione rapida dello Solfo contenuto nel Minerale." (*Rassegna Mineraria*, July 21, 1909; 2½ pp.)

White, E. F. "Sulphur Mining in Mexico." (*Mines and Minerals*, Sept., 1909; 1½ pp.)

Woodruff, E. G. "Sulphur Deposits Near Thermopolis, Wyoming." (*Bull.* 380, U. S. Geol. Surv., 1909; 8 pp.)

TALC AND SOAPSTONE.

By Richard H. Vail.

The diverse uses to which talc is put in the various industries would seem to entitle its products to separate consideration, as different physical qualities are demanded by nearly every industry. This is particularly apparent in the different fields of the soapstone or block products and that of the ground talc. The mineral is of extensive occurrence but the market, though diverse, is at the same time limited, and its volume hardly warrants further segregation than has been made below.

STATISTICS OF TALC AND SOAPSTONE IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

Year.	Production.						Imports.		
	Fibrous Talc.			Talc and Soapstone (b)					
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value	Value Per Ton.
1896........	51,816	$256,080	$4.94	21,448	$207,085	$9.66	1,950	$18,693	$ 9.60
1897........	52,836	283,685	5.37	27,068	259,948	9.60	779	8,423	10.54
1898........	54,807	285,759	5.21	27,974	237,280	8.48	445	5,526	10.70
1899........	57,120	272,595	4.77	26,682	241,267	9.04	254	3,534	13.91
1900........	45,000	236,250	5.25	26,726	249,777	9.35	79	1,070	13.50
1901........	69,200	483,600	6.99	28,643	424,888	14.83	2,386	27,015	11.32
1902........	71,100	615,350	8.65	26,854	525,157	19.36	2,859	35,336	12.36
1903........	60.230	421,600	7.00	26,671	418,460	15.69	1,791	19,677	10.99
1904........	65,000	455,000	7.00	27,184	433,331	15.94	3,268	36,370	11.13
1905........	67,000	519,250	7.75	40,134	637,062	15.87	4,000	48,225	12.06
1906........	64,200	541,600	8.43	58,972	874,356	14.82	5,643	67,818	12.02
1907........	59,000	501,500	8.50	72,010	905,047	12.57	10,060	126,391	12.56
1908........	70,739	697,390	9.86	46,615	703,832	15.01	7,429	97,096	13.07
1909........	65,000(c)	617,500	9.50	....	....	....	8,377	102,964	12.29

(a) Statistics for 1902 and subsequent years, are as reported by the United States Geological Survey, except that fibrous talc is as reported by the New York State Geological Survey. (b) The value of these products has not much significance owing to the diverse conditions of the material reported. (c) Estimated.

The output in the United States has been limited to the States of the eastern slope of the Appalachian Range on account of transportation and market conditions. The domestic production of ground talc and soapstone is now about 120,000 tons annually. In addition to this there was imported in 1909 over 8000 tons, mainly high-grade ground talc from France, Austria and Italy, though there was also some crude talc imported.

Talc is marketed under three general heads: (1) The ground fibrous talc used in paper making, this being obtained almost exclusively from the deposits in St. Lawrence county, New York, which State is the most important producer of talc in this country; (2) the massive variety, known as steatite, or soapstone, the supply of which comes mainly from Virginia; (3) ordinary ground talc of various grades produced in many of the Atlantic States, especially in Vermont, Massachusetts and North Carolina.

Talc production in the United States increased during 1909 over the output of the previous year in the varieties marketed as ground talc and soapstone, but there was a slight decline in the value and amount of fibrous talc produced in New York for the paper-making industry. The 1909 production of fibrous talc was, however, about normal. It was slightly less than that of the previous year on account of artificial stimulation in 1908, owing to the short stock at the end of 1907, the latter being the result of the burning of one of the principal mills in that field. The conditions governing the production of fibrous talc in New York are exceptional, the Gouverneur district having a practical monopoly of the field owing to the superior quality of this talc for book and writing paper. In no other States have deposits of this character been opened, and New York in consequence, has no competition in point of quality for talc suitable for the manufacture of book and writing paper.

Most of the other Appalachian States produce both soapstone and the ordinary foliated talc, the deposits of which, as a rule, are not extensive, and their economic importance depends primarily upon their proximity to transportation and market. Deposits of talc are not rare, and if of only ordinary grade, the mineral is seldom profitably shipped as mined. Most of the talc mined is owned or controlled by manufacturers or users, and in consequence the mineral usually finds its way into the market in the manufactured state. Varieties of unusual purity and quality are sometimes shipped as mined, but this is the exception rather than the rule, and the prices usually quoted are for the manufactured or finished product. The average value of the crude product sold in the United States is less than \$3 per ton; when sawed into slabs it has an approximate value of \$20 per ton; manufactured articles vary from \$20 to \$40 per ton, averaging about \$27. The ground talc varies from \$6 to \$20 per ton.

The ground talc enters a much diversified market, according as the various grades meet the qualifications required by the different industries. There is a good demand for the best grades, as is indicated by the importation of high-grade talc from Italy and France, notwithstanding an import duty on the ground product. This import duty was formerly 20 per cent. ad valorem, but, according to the ruling of the custom officials, the last tariff bill placed it in a new classification, requiring 30 per cent. ad valorem. This ruling, however, has been questioned and a decision is pending.

Prices and Market Conditions.—There was a better demand for talc in 1909, but the prices remained almost stationary throughout the twelve months. The prices for ground talc, according to quality and quantity, were from \$6 to \$20 for American talc, \$15 to \$25 for French talc, and from \$30 to \$35 for Italian talc. The price for fibrous talc for paper making was approximately \$9.50 per ton, f.o.b. Gouverneur, N. Y. The producers of soapstone and articles of soapstone manufacture received the benefit of improved business conditions in better prices and a wider market for their products. The latter are, however, so diversified that it is impracticable to give prices of the various articles within the scope of this review.

Talc in the United States.

Arkansas.—There is a large soapstone deposit in Arkansas, near Benton, in Saline county, but owing to lack of transportation facilities, the Arkansas Soapstone and Refractories Manufacturing Company which owns this deposit has not yet undertaken its commercial exploitation. A branch railway line to connect with the St. Louis, Iron Mountain & Southern Railway has been under consideration for several years, and if consummated the company expects to begin the manufacture of refractory products.

Georgia.—Talc occurs in Georgia in Murray county, where the Cohutta Talc Company and the Georgia Talc Company, of Chatsworth, own the most important deposits. No production is reported by these companies and no talc properties were operated on a commercial scale during 1909, though a small amount was obtained from development work.

Maryland.—The only talc producer in this State in 1909 was the Deland Mining and Milling Company, of Havre de Grace. The company operated the Bald Friar quarry and ground all its product. There are other deposits in Cecil and in Carroll counties. The soapstone deposit of the Steatite Corporation near Marriottsville is no longer operated. The property is equipped with a mill having a capacity of 40 to 50 tons of powdered talc per day, and machinery for producing 5000 sq.ft. of sawed slabs. The Cecil Mineral Company owns a deposit near Conowingo, Cecil county, but no production was reported.

Massachusetts.—The Massachusetts Talc Company of North Adams, Mass., continues to be the most important producer of talc in that State.

Its production was considerably increased in 1909. The company's mines are situated in Franklin county, about four miles from Zoar on the Fitchburg division of the Boston & Maine Railroad. The deposit is from 18 to 28 ft. wide and is operated from a two-compartment shaft 14x7 ft., sunk to a depth of about 200 ft. The property is equipped with a modern mill. The Berkshire Talc and Manufacturing Company, of Dalton, did not operate its property in 1909. Additional machinery has been installed, however, and the company plans to quarry and grind talc during the 1910 season.

New York. (By D. H. Newland.)—The year 1909 was a normal one in the talc industry of St. Lawrence county, and the production, for which complete returns have not been obtainable, may be placed at about 65,000 short tons. The value of the product was approximately $617,500, or an average of $9.50 per ton. Both the quantity and value were somewhat less than the totals reported for 1908, but the output in the latter year was stimulated by a shortage of production in 1907, due to the burning of one of the largest mills in the district.

Following the consolidation of producing interests by which the properties owned by the United States Talc Company and the Union Talc Company came into the control of the International Pulp Company, competition in the industry has been largely eliminated, at least for the present. The only independent producer last year was the Ontario Talc Company. The Uniform Fiber Talc Company has a mill under construction and is expected to begin mining operations during 1910. It has opened a deposit on Wintergreen hill, just west of Talcville. The St. Lawrence County mines are all situated in a single district which lies southeast of Gouverneur, the principal shipping point.

The existence of talc elsewhere in the Adirondack region has long been known, and a deposit near Natural Bridge, Lewis county, has been under development by the St. Lawrence Talc and Asbestos Company. The talc occurs there under conditions similar to those in the more northerly district, but it has little of the fibrous texture which is characteristic of the Gouverneur product. The deposit lies within a belt of crystalline limestones and schists that parallels the similar belt of St. Lawrence county in which the fibrous talc is found. The recent operations are reported to have revealed a large quantity of rock of good quality. The company is considering the erection of a mill.

North Carolina.—In this State two distinct minerals are mined and placed on the market as talc. Pyrophyllite, a hydrous aluminum silicate, while differing chemically from talc, which is a hydrous magnesium silicate, has many similar physical properties, and for certain uses it answers as well as talc. Pyrophyllite is mined especially in Moore county, while true talc deposits occur in Swain, Alexander, Graham and Cherokee counties. The talc produced by the Hewitt mine in Swain county is of excellent quality and has attained an international reputation. Pyrophyllite is mined near Glendon, in Moore county, by the Glendon Mining and Manufacturing Company, the Croatan Mining Company and the American Talc Company.

Pennsylvania and New Jersey.—Deposits of talc occur on both sides of the Delaware river in the vicinity of Phillipsburg, Warren county, N. J., and near Easton, Penn. The only property operating on a commercial scale in 1909 was that of John O. Wagener & Co., near Easton.

Vermont.—The outcrops of talc in this State are numerous, and vary greatly in quality. Some of the deposits are exceedingly pure and of excellent color, while the product of other deposits is more or less injured by the presence of iron and silica. Most of that mined is the ordinary massive variety, but in several localities there is foliated talc in small quantities. Soapstone has been quarried and used in Vermont since the advent of the earliest settlers, and in many parts of the State old and long-abandoned quarries are found. Few of these deposits, however, furnish sound slabs of such size as are needed for tubs and similar objects. Many of the mines produce both soapstone slabs and ground talc, but some produce only one of these products. The principal soapstone producers are the Union Soapstone Company and the American Soapstone Finish Company at Chester, and the Vermont Soapstone Company at Perkinsville. Ground talc is produced by the American Mineral Company at Johnson, the Eastern Talc Company at East Granville, the Vermont Talc Company at Windham, the United States Talc Company at Rochester, and the Vermont Talc and Soapstone Company at Chester Depot.

Virginia.—The principal supply of soapstone in the United States now comes from Albemarle county, and the Virginia Soapstone Company with its affiliated marketing company, the Alberene Stone Company, is the dominant factor in this market. Its property is at Alberene, the products from these quarries being sawed into slabs, and much of it used in plumbing fixtures, such as laundry tubs, laboratory tables, etc. The Old Dominion Soapstone Company has quarries at Esmont and is the only other producer of importance in Virginia.

Talc in Foreign Countries.

The chief sources of talc in Europe are in the French Pyrenees and in the Italian Alps. Talc production is increasing in Austria, however, and that country is now exporting several thousand tons annually. The best grades of talc come as a rule from Italy, though some of the French and Austrian deposits produce talc of almost equally high grade. Though not of international importance, limited talc operations are conducted in China, Brazil, and India. There are known deposits in New Zealand, Australia, and, in fact, in nearly all countries, though commercial considerations do not permit of the extensive operation of such deposits. Foreign talc is imported into the United States mainly in the powdered form, though there is also received a limited quantity of rough rock, soapstone slabs for use in plumbing work, and blocks for making gas tips and other small articles of manufacture.

Austria.—The important talc deposits of Austria are controlled by M. Elbogen of Vienna, the largest operations being in the commune of Floing. The Austrian production is increasing and during 1909 about 2000 tons were exported to the United States.

Brazil.—Owing to the inaccessibility of many of the Brazilian deposits of talc, the production has been limited to the beds near the cities of Sâo Paulo and Loreno in the state of Sâo Paulo. The talc from the latter deposit is of good quality, but is usually marketed in three grades, according to color.

Canada.—In the vicinity of Madoc, in the Province of Ontario, a talc deposit is being worked and a mill has been erected, so that much of the product which was formerly shipped to the United States in crude form is now being ground at the property. The crude product is valued by the Canadian Department of Mines at about $3 per ton, and in 1909 approximately 4500 tons were mined.

France.—About 30,000 tons of talc are mined annually in France, the principal deposit occurring in the Pyrenees, in the department of Ariège. Talc is also mined in the departments of Aude, Lot, Loire Haute, and Pyrenees Orientales. Some of the talc is of excellent quality, nearly equaling that of the best Italian grade, though much inferior talc is also shipped. The important deposits at Luzech are of excellent quality, being of a whitish or bluish white color, much appreciated by consumers in certain trades. The beds are situated at the contact of the massive St. Barthelémy granites and the old schists, about 7 km. from Luzech, at an altitude of from 1500 to 1800 m. The deposits are operated as quarries and four qualities of talc are produced. The "extra quality" consists of blocks of steatite averaging 200 to 250 cm. on each side; the "first quality" is small pieces of steatite which are perfectly white and almost translucent, this grade being pulverized and used in talcum powders; the second and third grades have limited use because of impurities, principally organic matter and iron products from the decomposition of adjacent pyrite beds. The principal ports of export are Havre, Bordeaux and Marseilles, importations into the United States coming principally from the first-named port. The crude talc is worth at the mines about $6 per metric ton, and on this basis the production now exceeds 1,000,000 fr. annually. About one-sixth of the French production is sent to the United States.

India.—The production of talc on a commercial scale in India is slowly increasing. The annual production is now about 800 tons, most of this coming from the Central Provinces. A small amount was produced in Burma.

Italy.—Talc is mined in Italy in the northern part, especially in the vicinity of Pinerolo in the Italian Alps and is usually shipped from Genoa. It has long been mined in the valley of the Chisone and that of San Martino. The premier grades of talc in the world are produced in this country, the Italian talcs bringing the highest prices and finding their main use in toilet and medicinal preparations on account of their superior color and absence of gritty or hard material. Inferior talcs are, of course, produced, but the greater portion of the Italian talc imported in the United States is of the higher grade. The product at the mines is valued in the Government report at $11 per ton and about 11,000 tons of talc are mined annually.

Occurrence, Uses and Methods of Mining.

Occurrence.—Though a mineral of almost universal occurrence, many deposits of talc are not so situated in relation to transportation and market as to make their development profitable. There are numerous varieties, the most important being the foliated talc and the massive variety known as steatite or soapstone. It is a hydrous silicate of magnesium, $H_2O.3MgO.4SiO_2$, having a greenish, whitish or gray color. It is derived from the alteration of pyroxene, amphibole, enstatite, and other magnesium silicates, and is often associated with dolomite, serpentine or magnesite. Deposits of economic interest occur in the United States in most of the States lying along the eastern slope of the Appalachian range. Both the foliated talc and the amorphous steatite occur in nearly all of the States.

Uses.—In the form of soapstone slabs, talc finds a wide use in chemical laboratories, hospitals, urinals, acid tanks, etc., as it is highly resistant to all ordinary acids except hydrofluoric. It is not easily affected by heat and is extensively used for gridles, hearthstones, laundry tubs, sinks, gas tips and for marking pencils such as tailor's chalk, pencils for marking on iron and glass, and the ordinary slate-pencil of the schoolroom. Having great dielectric strength, requiring 30,000 to 40,000 volts to pierce a ½-in. slab, it is used for the flooring of electric stations and other electrical uses. As the soapstone is soft and easily shaped, it is often used for making images, particularly in such countries as China and Japan.

Powdered talc is used in the manufacture of paper, toilet powders, foundry facings, sizing for cotton cloths, insulated covering for wire, facing for rubber molds, dressing for skins and leathers and, to some extent, in inferior grades of soap and paint, particularly enameled paint. The "French chalk" of commerce is mainly powdered talc. Aside from its legitimate uses, talc has been used as an adulterant in numerous trades, and this fact is partly responsible for the attitude of secrecy prevailing among many producers and users, and also explains the reticence of jobbers of talc products in giving information or statistics concerning its uses.

The value of powdered talc depends on physical qualities and is judged by its color and its "feel" or slip. The whitest talcs, or those with a bluish white shade, demand the highest price. The poorer grades have a yellowish hue, and a portion of the French output has this defect. The Italian talc is the whitest and best for such purposes as the talcum toilet powders which have come into extensive use in recent years. Some of the best grades of domestic talc are also used in these powders. Talc of good slip, or free from grit, is used in the sizing of cotton cloth, regardless of its color, but freedom from grit, which dulls the cutting knives, is essential in this trade.

The fibrous talc of New York State is especially valuable as a filler in the manufacture of book and writing paper, as it increases the strength of the paper and reduces the brittleness characteristic of paper weighted with clay or inferior grades of talc. Although apparently granular when ground to 100 mesh, its fibrous character is still maintained and is readily observed under a microscope. The fibrous talc is superior to the ordinary foliated talc, in that a larger proportion is retained in the paper pulp. This is particularly true, as compared with the china clay formerly used, of which only about 30 to 35 per cent. was retained in the pulp, as against 75 to 90 per cent. when the fibrous talc is used. In newspaper, however, South Carolina clay is still used.

Mining Methods.—The valuable deposits of soapstone occur usually in flat beds or lenses, without any well developed cleavage, and when possible are worked by open cut in order to obtain a large proportion of the output in the form of slabs, which are more valuable than the powdered form. Owing to its lack of cleavage, it has to be cut on all sides to obtain the best results, and channeling machines have, in consequence, been introduced for this work at some of the Virginia quarries. The channeled blocks are taken to gang saws which produce slabs about 1½ in. thick. These are then planed, grooved and finished on rubbing beds for manufacture into various products, or shipped in slab form from the quarries.

When talc is to be powdered and the deposit persists in depth, the usual mining methods are employed in breaking the mineral. Practically all of the fibrous talc mined in the Gouverneur district in St. Lawrence county, N. Y., now comes from underground workings, which have attained a depth of over 200 ft. Blasting is practised and ventilation easily accomplished by connections with the numerous workings. The mines are practically dry and the mineral does not require artificial drying before going to the fine-crushing department. In fact, on leaving the pebble mill the product has acquired sufficient heat to be readily perceptible when it is handled.

As the material comes from the mines it is passed over grizzlies, and the coarse material is broken in a jaw crusher, from which the product is sent to rolls and is further reduced by buhr mills. The product from the latter is sent to tube or pebble mills, where it is reduced to 80 or 100 mesh. Much of the material in this district is not bolted, as such fineness is not essential for the paper-making industry. In the mills in other States the talc is usually bolted to secure the fineness required by most industries.

TANTALUM.

Tantalum is one of the most remarkable and interesting of the rare metals. It has a very high melting point (about 2300 deg. C.) and is not corroded by ordinary acids or bases. The physical and chemical properties of the metal and its alloys, together with its ores, metallurgy and use for electric lamp filaments, were described in detail in Vol. XVII. of The Mineral Industry. One of the recent applications of the metal is for surgical and dental instruments, for which it appears to be particularly adapted. Its use for this purpose has been patented[1] by Otto Neugebauer, of the Siemens & Halske Company, Berlin, Germany. The advantages claimed are that instruments made of the metal, alloyed with a small quantity of carbon, are harder than the hardest steel, are not attacked by ordinary acids, and may be readily cleaned and rendered aseptic. Dental tools of tantalum are not discolored by mercurial alloys, or affected by iodine, and unlike steel instruments they may be used with trikreosol acids and do not color porcelain or silicate fillings. Another recent application of tantalum is for watch springs, and its use for this purpose has been patented.[2] While tantalum springs may be made as resilient as steel, they do not become magnetic and are non-corrodible.

The discovery of native tantalum, hitherto unknown, was reported in 1909. The metal was found associated with a small fraction of niobium, and was obtained from a placer mine in the Urals. From a commercial standpoint the discovery was of no importance, the whole amount collected being only a few grains, but scientifically it adds another to the comparatively meagre list of native metals.

Prices.—The values of the ores and alloys of tantalum are subject to wide fluctuations. In December, 1909, English dealers quoted as follows: For ferro-tantalum of 65 to 75 per cent. Ta, 14s. per ℔. of contained tantalum; tantalum ore of about 60 per cent. Ta. 205@220s. per 112 pounds.

---

[1] U. S. pat. 940,351, Nov. 16, 1909.
[2] U. S. pats. 646,993, 947 146 and 947,147, Jan. 18, 1910.

TIN.

Although the United States is the largest consumer of tin, taking about 40 per cent. of the world's output, nothing more than an insignificant quantity has ever been produced in this country and none whatever was produced in 1909. No work was done at Gaffney, South Carolina, where some concentrates were produced in 1908, but it is understood that there will be a resumption of operations at that place. Some further prospecting was done in Alaska, but that Territory is still far from promising to be a factor of consequence in the tin supply of the world. The most promising steps toward the development of a tin mining industry in the United States in 1909 were made in South Dakota and in Texas.

THE PRINCIPAL TIN SUPPLIES OF THE WORLD. (*a*)
(In tons of 2240 lb.)

	1901	1902	1903	1904	1905	1906	1907	1908	1909
English production	4,566	4,392	4,282	4,132	4,468	4,522	4,407	5,052	(*b*)5,200
Chinese production (Yunnan)	3,026	3,788	2,443	2,979	4,463	3,948	3,480	4,558	(*b*)4,200
Straits to Europe and America	50,339	51,831	52,212	57,419	56,840	57,143	53,520	60,491	58,521
Straits to India and China	2,655	1,882	3,123	3,261	1,484	1,292	2,178	2,187	2,030
Australia to Europe and America	3,345	3,199	4,934	4,846	5,028	6,482	6,612	5,748	5,384
Banka sales in Holland	14,978	14,978	15,070	11,363	9,960	9,286	11,264	11,530	11,973
Billiton sales in Java and Holland	4,387	3,897	3,650	3,215	2,715	1,968	2,229	2,235	2,241
Bolivian arrivals in Europe	9,670	10,150	9,630	12,978	14,245	16,394	15,594	17,032	18,121
Totals in long tons	92,966	94,117	95,344	100,193	99,203	101,035	98,284	108,833	107,670
Totals in metric tons	94,458	95,628	96,874	101,802	100,795	102,657	99,861	110,580	109,398

(*a*) Compiled from commercial reports. There is also a small production in Germany. (*b*) Estimated.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1901	74,560,487	$19,024,761	1904	83,168,657	$22,356,896	1907	82,548,838	$32,075,091
1902	85,043,353	21,263,337	1905	89,227,698	26,316,023	1908	82,503,190	23,932,560
1903	83,133,847	22,265,367	1906	101,027,188	37,446,508	1909	95,350,020	27,559,937

Alaska.—The known tin deposits of Alaska that promise to be of commercial importance are situated in the extreme western part of Seward peninsula. Adolf Knopf states that at present four places are being prospected for tin. They are included within an area of 400 square miles, situated about 100 miles northwest of Nome. In geographic order from north to south, these four are Ear mountain, Buck creek, Cape mountain and Lost river. The tin occurs in both placer and lode form. Up to the end of 1908 the total production of the entire region was 160 tons of cassiterite concentrates, all of which, except a few tons from lode deposits, came from the stream tin of Buck creek.

South Dakota.—The tin deposits of the Black Hills occur in two districts, commonly known as the Northern and Southern. The deposits in the Northern are in the vicinity of Spearfish, where the most active company is the Tinton Mining Company, with mines at Tinton, 16 miles from the railroad. This company is said to have developed a fairly large tonnage of ore which is expected to yield 10 ℔. of tin per ton. A few lots of concentrates have been shipped, but the company apparently has not yet been able to undertake the exploitation of its property upon the large scale that is necessary for success.

In the Southern district are the properties of the old Harney Peak Tin Mining Company, which are now in the hands of the Pahasa Mining Company. The litigation involving these properties was unraveled in 1909 and the way was made clear for the resumption of exploration, which was undertaken under the direction of Dr. A. R. Ledoux.

Texas.—Mines situated on the eastern slope of North Mount Franklin, about 10 miles north of El Paso, and five miles west of the El Paso & Southwestern railroad, are being developed by the El Paso Tin Mining and Smelting Company, under the direction of Walter E. Koch. According to Mr. Koch, the tin-bearing area consists of true fissure veins of quartz carrying cassiterite, and of zones of impregnation in granite. The cassiterite occurs disseminated through the quartz and in masses. The company has erected a pneumatic concentrating mill which is expected to be in operation in the latter part of 1911.

Tin Mining in Foreign Countries.

Australia. (By F. S. Mance.)—In Tasmania the output of tin ore was well maintained, the official returns for 1909 giving the yield as 4511 tons, valued at £418,165. The vigorous policy of prospecting adopted at the Mount Bischoff mine has resulted in the ore reserves being considerably augmented, and the existing plant was largely increased with the object of adding to the output and reducing working costs. The company was enabled to maintain the remarkable run of dividends, which have now reached a total of £2,187,000, or £182 5s. per share. The Briseis mines continued to furnish tin ore in good quantity.

In Queensland the industry shows a marked retrogression compared with 1908. The value of the output for 1909 totaled only £244,927, or £97,264 below that of the preceding year. The decrease is almost wholly due to labor troubles causing a cessation of operations at the principal mines during the earlier months of the year. In the Herberton and Chillagoe fields new lodes have been opened and more extensive ore bodies have been disclosed in some of the principal mines, so that the future outlook is brighter. At the Stannary Hills mine a new plant was erected, and the central shaft carried down to a depth of 500 ft. Prospecting disclosed the existence of several ore bodies said to be payable, but these have not yet been opened. The Vulcan mine showed considerable improvement during the latter months of 1909, and there was a marked increase in the output. The latest reports indicate that a continuation of good crushings may be looked for, as operations have disclosed the existence of bodies of ore in portions of the mine previously regarded as worked out. The main shaft at this mine was put down to a depth of 1450 ft. The Smiths Creek mines continue to produce a considerable quantity of ore, and the work of development is progressing on satisfactory lines.

In New South Wales the dredges continued to furnish the bulk of the yield, but some of the richer areas have been worked out, and a steady diminution in the yield must therefore be expected in the future. The value of the tin and tin ore produced in this State during 1909 was £211,029, or £5582 more than in the preceding year.

In West Australia the output of tin ore has been on a restricted scale, but it is expected that the construction of the Port Hedland & Marble Bar railway will give a stimulus to production.

The exports of tin ore from the Northern Territory of Australia in 1909 amounted to 416 long tons.

Austria.—During the last three years steady prospecting work has been carried on by Karl Häusler, mining engineer, of Töplitz, at Frühbuss, Sauersack, Hirschenstand, Neudeck, and Grasslitz, with a view to discovering tin ores. Mr. Häusler has now obtained 16 mining rights in the districts of Hirschenstand and Sauersack, and has organized a company to exploit them.

Banca and Billiton.—According to a U. S. consular report the 12 auctions at Batavia in 1909 resulted in total sales of 36,393 pikuls (Java pikul=136 lb). The government shipments of tin in 1909 amounted to 166,308 pikuls of Banca and 5986 pikuls of Sumatra, while private shipments were 29,809 pikuls. The total exports in 1908 were 193,635 pikuls of government Banca tin, and 35,779 pikuls of private Billiton tin. The total shipped in 1907 for government account was 179,300 pikuls of Banca tin, and for private account 37,979 pikuls of Billiton tin.

According to the London *Min. Journ.*, the production of the Banca tin mines for 1909-10 amounted to 261,146 pikuls, as compared with

203,990 pikuls in the previous year. This large increase, coupled with the announcement of increased sales and, apparently, a more active recruiting policy, gave rise to more or less sensational estimates of progressive increases in future years. These were, however, largely exaggerated. The production last year was exceptional, partly on account of an abnormal influx of Chinese coolies, but mainly owing to the year having consisted of 13, instead of 12, and even 11 months, as is sometimes the case. It is the intention of the responsible authorities to reduce the output for the current year to between 200,000 and 250,000 pikuls; and while this figure is somewhat beyond the production of recent years, it is clear that there is at present no intention to enlarge the output further.

The report of the Billiton Tin Company for the fiscal year 1908-9 showed a production of 66,684 pikuls, as against 66,491, 63,310, and 67,386 pikuls during the three previous years. In this production is included 29,900 pikuls of tin obtained from the 43,384 pikuls of tin ore and 326 pikuls of "natrat" tin sent to Singapore for smelting and sale. The total labor amounted on April 30, 1909, to 14,719 men, as against 13,950 in the previous year. The output per head was 6.22 pikuls, as against 6.43, 7.42, and 8.07 in the three previous years. This decrease took place in spite of exceptionally favorable weather. At the mines and "shifts" there were at work during the year an average of 10,691 men, as against 10,331, 8400, 8349, and 7867 men during the previous four years. Estimates had been made for a force of 12,762 men. The average earnings of the miners employed was 267 fl. (£22 5s.), as against 260 fl. (£21 13s. 4d.) in the previous year.

In the new fiscal year, with a force of a mean average of 11,300 miners, and with normal weather conditions, a production of 62,000 pikuls is expected, to which is to be added 4000 pikuls of tin as the expected production of the suction dredge, which came into operation about Aug. 15, 1909. On April 15, 1909, reserves were estimated at 16,791½ "nachts" of ore, equal to upward of 470,000 pikuls of tin, calculating the "nacht" of ore at 28 pikuls. No discovery of new tin fields on the island of Billiton can be expected, but with the boring now in progress a limited amount of poor ground should be found on previously worked-out fields. The exploitation of such ground cannot be undertaken by ordinary hand labor without loss with tin below present quotations. Even if it prove possible to keep these fields in exploitation by mechanical means, then the quantity of tin to be obtained will not be sufficient for more than a limited number of years—at least, if production be kept at 60,000 pikuls annually.

Although it thus appears that the future of the alluvial tin mining in Billiton is limited, yet the possibility remains that deep level mining on the existing ore courses will make it possible to continue production for many years after the exhaustion of alluvial ores. The chances for a paying deep level exploitation are encouraging. Considerable capital will however, have to be expended in installations for underground work. The board has consequently approached the Government with a proposal of a renewal of the existing concession, which expires in 1927.

Bolivia.—According to recent British consular reports, the production of tin in Bolivia during 1908 was as follows: Potosi, 18,139 tons; Oruro, 9620; La Paz, 2008; Cochabamba, 170; total, 29,937. Tin mining is still almost the only industry of the Oruro district. Several new workings have just been begun in the Huanuni, Morocacala, and Negro Pabellon districts, and an increased output is expected in 1909. One mine is now shipping 10 tons per day of 58- to 60-per cent. ore without treatment, save picking at the mine. Several completely new dressing works have been erected, on which about £250,000 have been spent; but, unfortunately, in most cases very little has been expended in developing the mines.

RECEIPTS OF BOLIVIAN TIN AT LIVERPOOL, HAVRE AND HAMBURG.(a)
(In tons of 2240 lb.)

Year.	Bars.	Ore. Crude Weight.	Ore. Metallic Content.	Total Tin.	Havre. Tons Fine.	Hamburg. Tons Fine.
1900	1,507	5,431	3,530	5,037	......	......
1901	1,730	9,086	5,905	7,635	......	......
1902	1,685	10,961	6,576	8,261	......	......
1903	1,614	10,401	6,240	7,854	......	......
1904	1,573	13,824	8,294	9,867	......	......
1905	1,386	17,504	10,504	11,888	......	......
1906	1,569	20,489	12,293	13,862	691	1827
1907	1,143	18,532	11,119	12,262	924	2390
1908	1,174	21,502	12,901	14,075	863	2056
1909	834	22,859	13,716	14,550	1216	2275

(a) As reported by H. A. Watson & Co., Liverpool.

The Bolivian tin production mostly comes from four or five districts—Huanuni, Uncia, Potosi, and Chorolque, La Paz, Berenguela, Avecaya-Antequera. It costs £22 to send a ton of 65-per cent. *barrilla* to the United Kingdom. Generally only the poorer and less developed parts of the mine are rented to *pirquineros;* £1 8s. 10d. may be taken as a fairly high price in this district for metal of 60 per cent. and 16s. for 50-per cent. ores. In 1908 one company showed a cost in the mine of about 20 bols. (say £1 10s.) per quintal for a production of nearly 2000 tons, of which over four-fifths gave an assay of over 69 per cent. metallic tin. A smaller company is now producing about 800 quintals per month at a monthly cost of £2000, and that from ore that barely averages 3 per cent., which is very low for this district, and still making a profit.

A correspondent of the London *Mining Journal* gives the production of tin in Bolivia in 1909, in metric tons of *barilla* or concentrates, in which form it is nearly all exported, as follows: Potosi, 24,051; Oruro, 9193; La Paz, 1812; Cochabamba, 510; total, 35,566 tons. As the *barrilla* averages 60 per cent. metal, this is equivalent to 21,340 metric tons of metallic tin. The largest mine in Bolivia is the Salvadora at Uncia in the department of Potosi, which produces from 700 to 1000 tons of *barrilla* monthly.

EXPORTATION OF TIN FROM BOLIVIA.
(In metric tons.)

Year.	Barrilla. Tons.	Metallic Tin. (a) Tons.	Year.	Barrilla. Tons.	Metallic Tin. (a) Tons.
1898....	4,327	2,596	1904....	20,369	12,221
1899....	9,134	5,480	1905....	27,690	16,614
1900....	15,088	9,053	1906....	29,370	17,624
1901....	21,573	12,943	1907....	27,678	16,607
1902....	17,340	10,404	1908....	29,938	17,963
1903....	21,785	13,071	1909....	35,566	21,340

(*a*) Tin content of the barriall (black tin concentrate), computing the latter at 60 per cent. metallic tin.

E. A. L. De Romaño, in *Boletin* del Cuerpo de Ingenieros de Minas del Peru, 1908, No. 57, pp. 1-99, reports that tin mining in Bolivia is probably an industry of ancient date. The stanniferous deposits are scattered along the eastern Cordillera of the Andes, from 15° to 21° latitude S., the northernmost occurrence being that of Carabuco, about 22 miles distant from the Peruvian border, and the southernmost of any importance being that of Chorolque. This eastern Cordillera is a gigantic axis, upon which rest Silurian and Devonian schists, slates, and sandstones, often highly metamorphosed. In the neighborhood of the important mining center of Oruro, the rocks are greatly dislocated, and have yielded passage to rhyolitic eruptions which have assumed the form of dikes and sills. The stanniferous lodes traverse the rhyolites and the neighboring sedimentaries, but their association with the granites has not yet been proved. One of the most salient characteristics of the Bolivian tin-ore occurrences is, in fact, their association with Tertiary eruptives, instead of with ancient granulites. The rhyolites are much decomposed in the vicinity of the tin lodes, and apparently this alteration is due to the mineralizing solutions from which the metalliferous particles were deposited. The lodes vary greatly in thickness, rarely attaining a maximum of 4 or 5 ft., and the thinner lodes (less than 2 ft.) are generally the richer. The widest lodes assume more or less the character of a metallized breccia of country-rock, instead of the clean, well-marked fissures infilled by the narrower lodes. Tin lodes are also found in great numbers traversing quartzites; these rocks, forming a very resistant medium, were more cleanly fissured than the more yielding rocks at the time of the above-mentioned earth-movements. In the Cerro de Chualla, for instance, the main lodes traverse the quartzites, but lose all importance so soon as they pass from these into the clay-slates.

The deposits in the vicinity of Oruro are nearly all linked up by good cart-roads with the narrow-gage railway to Antofagasta. Water power is not available, as the small streams running down from the Cordillera furnish barely enough water for the concentration of the ores. If sufficient capital were forthcoming adequate power could be got from the more distant cataracts and lakelets of the Cordillera de Tres Cruces.

The price of coal at Oruro is at present prohibitive; but it would seem possible to make use of "explosion-motors," the necessary fuel being supplied by the distillation-products of the petroleum got from the Pusi deposits "on the lake-shore" (Titicaca), supposing that these prove to be of industrial importance. Around La Paz the tin mines are almost invariably equipped with hydraulic installations, which draw their supply from the great snow peaks of the district. Nevertheless, hand labor is used, to an exaggerated extent, and is consequently expensive. The laborers are Airaraes "Indians," much addicted to liquor, and, moreover, thievish and vindictive. The adits are generally near the hill-tops, where erosion had laid bare the outcrop of the lodes, and in most of such mines the crude ore is sent down by aërial tramways to the smelteries in the valley below. In some few cases where the ore occurs, more especially among the decomposed rock, it is got by hewing with the miner's pick. Water trouble is of such little consequence in the workings that, as a rule, a pumping plant is found unnecessary.

(By J. Aguirre-Acha.)—Bolivia furnishes nearly 19 per cent. of the world's production of tin, and a large increase is expected when the railroads that are in actual construction are completed. The following statistics are from a careful study of the production of tin by Casto Rojas, subsecretary of the treasury. The fineness that is generally calculated for the cassiterite or *barrilla* exported from Bolivia is 65 per cent., but the production of tin in the last nine years is given in the accompanying table on a basis of only 60 per cent.

There are now two railroads leading to the high table-land from the coast of Chile and Peru; another, coming from the Argentine, will soon cross the southeastern part of the republic; and a fourth will unite more intimately almost all the mining zone of Boliva with the port of Arica. There is thus a total of nearly 700 miles of railroad constructed up to the present time and an equal amount in construction and projection, without including in these figures the Madeira-Mamore railroad, on the Brazilian-Bolivian frontier.

PRODUCTION OF TIN IN BOLIVIA.

Year.	Cassiterite, Kg.	Tin, Tons.	Year	Cassiterite, Kg.	Tin, Tons.	Year	Cassiterite, Kg.	Tin, Tons.
1900	16,231,200	9,740	1903	(a)	(a)	1906	29,373,538	17,624
1901	21,915,900	13,149	1904	21,545,703	12,927	1907	27,677,780	16,608
1902	17,608,300	10,564	1905	27,689,621	14,613	1908	29,938,828	17,962

(a) No figures available.

PRINCIPAL MINING COMPANIES IN BOLIVIA.

Companies.	Metals.	Home Offices.	Companies.	Metals.	Home Offices.
Compañia Huanchaca	Silver.	Huanchaca.	Compañia de Guanuni	Tin.	Oruro.
Compañia del Socavon	Silver.	Oruro.	Compañia de Negro Pavellón	Tin.	Oruro.
Compañia de San José	Silver.	Oruro.	Compañia de Morococala	Tin.	Oruro.
Compañia Colquechaca Aullagas	Silver.	Colquechaca.	Compañia de Colquiri	Tin.	Oruro.
Compañia Gallofa	Silver.	Colquechaca.	Roberto Peláez	Tin.	Oruro.
Compañia Consolidada	Silver.	Colquechaca.	Jerman Fricke & Co.	Tin.	Oruro.
Compañia Guadalupe	Silver.	Potosí.	Simon I. Patiño	Tin.	Oruro.
Compañia de Porco	Silver.	Potosí.	Juan B. Minchin	Tin.	Oruro.
Compañia de Portugalete	Silver.	Potosí.	Compañia Llallagua	Tin.	Llallagua.
Compañia del Real Socavon	Silver.	Potosí.	Soux & Hernández	Tin, silver.	Potosí.
Compañia de Andacaba	Silver.	Potosí.	Alfredo Meting	Tin, silver.	Potosí.
Nueva Compañia de Lípez	Silver.	Santa Isabel.	Bebin Hermanos	Tin, silver.	Potosí.
Compañia de Berenguela	Tin.	Arque.	M. Diaz & Co	Tin, silver.	Potosí.
Compañia de Colcha	Tin.	Arque.	Urriolagoitia & Co	Tin, silver.	Potosí.
Compañia de Milluni	Tin.	La Paz.	Compañia de Huaina Potosí	Tin, silver.	La Paz.
Andes Tin Company	Tin.	La Paz.	Aramayo, Francke & Co.	Tin, bismuth, silver.	Tupiza.
Benedicto Goytia	Tin.	La Paz.	Penny & Duncan	Tin, silver, copper.	Oruro.
Jorge Machicado	Tin.	La Paz.	Compañia de Corocoro	Copper.	Corocoro.
Franco Hermanos	Tin.	La Paz.	Berthin Freres & Co.	Copper.	Corocoro.
Pascual Cesarino	Tin.	La Paz.	Compañia de la Chacarilla	Copper.	Corocoro.
Harrison & Bötiger	Tin.	La Paz.	Compañia Los Angeles	Copper.	Corocoro.
Matias Mendieta	Tin.	Potosí.	Compañia de Chuquiaguillo	Gold.	La Paz.
Julio Martens	Tin.	Potosí.	Compañia de Yani	Gold.	La Paz.
Artruro Arana	Tin.	Potosí.	Incahuara Dredging Co.	Gold.	La Paz.
Lucio Leiton	Tin.	Potosí.	Compañia del Rio de San Juan	Gold.	Tupiza.
Juan Rubarit	Tin.	Potosí.	Compañia de Amayapampa	Gold.	Potosí.
Víctor Fuentes	Tin.	Potosí.			
Compañia de Monte Blanco	Tin.	Potosí.			
Compañia de Chocaya	Tin.	Potosí.			
Compañia de Avicaya	Tin.	Potosí.			
Compañia de Antequera	Tin.	Oruro.			

Burma.—The Southern Shan States Syndicate is developing the Mawchi deposits, comprising both lode and alluvial occurrences of tin ore.

China.—Practically all of the tin produced in China is derived from the Kotieou mines, 30 miles from the railroad, in the province of Yunnan. During the last 17 years the recorded output, according to W. F. Collins, in *Bull.* No. 63 of the Institution of Mining and Metallurgy, has shown a steady increase, from 2.7 per cent. in 1891 to 4.2 per cent. of the world's production in 1908.

The whole industry is in the hands of the Chinese, and any interference by Europeans is strongly resented. Methods are primitive in the extreme. Smelting is carried out in furnaces that have been evolved under local conditions. The chief difficulties are an absence of water for concentrating the ore, and the high price of charcoal for smelting. It is anticipated that the completion of the railroad will have a stimulating effect on the development of the industry.

None but alluvial deposits are now worked. There are about 150 mines scattered over an area 25 miles long by 20 miles broad. The deeper deposits are the richest and in this case the open-cast method of mining has been abandoned for true underground work. The tin ore usually contains a little magnetite and as much as 55 per cent. hematite. There is always a small percentage of lead in the ore. The amount of ore mined in any year is chiefly dependent upon the rainfall and the amount of capital available. Since almost all of the companies are small, the working expenses have to be paid directly by the output, which is sold as concentrate. Little mining is done until the rainy season, which usually lasts from May to September.

TIN PRODUCTION IN THE YUNNAN PROVINCE, CHINA.

Year.	Production, Long Tons.	Year.	Production, Long Tons.	Year.	Production, Long Tons.	Year.	Production, Long Tons.
1891......	1,741	1896........	2,013	1901........	3,026	1906........	3,948
1892......	2,063	1897........	2,476	1902........	3,788	1907........	3,480
1893......	1,923	1898........	2,733	1903........	2,443	1908........	4,558
1894......	2,343	1899........	2,568	1904........	2,979		
1895......	2,429	1900........	2,898	1905........	4,463		

The mines were, until recent years, subject to a code of provincial mining regulations. These regulations have been abolished in favor of the temporary regulation of the Imperial Government. The mineral now belongs to the Government and neither prospecting nor mining may be done without permission from Peking. The miners pay no direct taxes to the Government. The bulk of the taxation is borne by the smelters, aggregating about 12½ per cent. of metal value. In addition to these taxes the metal pays a maritime export duty of 60c. per 133 lb. Practically all of the tin is exported to Hongkong where the greater part of it is refined by Chinese merchants for European consumption. The accompanying table shows the output for a number of years.

According to a correspondent of the London *Min. Journ.*, writing from Yunnanfu, under date of May 13, 1910, the tin mines had another prosperous year in 1909. Rains were again early and copious, but the supply of labor was not so large as expected. Many of the coolies thrown out of work on the approach of completion of the Yunnan railway were either sent back to their own provinces or found work at the mines too arduous and not sufficiently remunerative. The customs returns for the year will show an output of about 4200 tons. Attempts have been made by a European firm to co-operate with Chinese merchants and officials in putting up a slag-cleaning plant near Mengtze, but the conditions have not yet been studied in sufficient detail for a decision on such a scheme to be taken.

The railway was officially inaugurated at Yunnanfu on March 31, and is now handed over to the French company formed for its exploitation. The large number of curves and heavy grades cause working expenses to be great, and freight charges are consequently excessive. Its presence has given no great stimulus to tin production. The effect is simply one of insuring the merchants against small losses by theft and junk-wreck on the Red river, to which they were previously liable. Transit is slightly more rapid, but there was no communication between Mengtze and the sea from June to September on account of heavy falls of earth in the Namti valley, caused by the rains. Expectation of the same difficulty this year caused the native companies to rush all metal available to Hongkong before the rains.

In accordance with long-established custom the Chinese mining companies have received payment for their tin concentrates in kind, consisting of coolies' clothes, rice, etc. The coming of the railway is changing this, and payment is now frequently made in dollars. This money is obtained in exchange for tin metal from the merchants in Hongkong, and Mexican as well as Hupeh dollars are now being imported into Kotieou by the ton.

In order to facilitate customs operations the weight of the half-horse-charge slab of tin has, until recently, been assumed to be 55 catties. Since the adoption of the new form of slab the metal has not lost weight in transit, with the result that the pieces, on their arrival at the customs station, turn the scale at a figure nearer 56 catties, with a consequent avoidance of payment to the Imperial customs revenue. Taxation on a basis of 56-catty slabs was consequently started, but so great was the influence and opposition of the merchants that an arrangement has been made by which duty is only paid on 55.5 catties. In consequence, the statistics of Yunnan production will be, approximately, 1 per cent. low for the future.

(By T. T. Read.)—There was a slight decrease in the production of tin in 1909, Yunnan (Mengtze), the principal district, showing a shrinkage from 5100 short tons to 4700 tons, and the total for the Empire decreasing from 5350 to about 5000 short tons.

Germany.—According to the report of the Essen Chamber of Commerce for 1909, the German tin smelters are unfavorably situated in comparison with their English competitors, with regard to the obtaining of the raw material, labor, coal and freight. During 1909 the German industry suffered acutely, owing to the necessity for producers to dispose of a large proportion of their output abroad, where it has to face English competition. The home market was further restricted by the specifications insisted on by the Prussian state railways for the tin consumed by them. These specifications were drawn up at a time when there was no home tin industry, and require the supply of certain marks of tin that are produced in the East Indies exclusively, and have to be imported via England and Holland. The German tin smelters claim to be able to produce a metal capable of complying with all reasonable requirements for railway purposes; and they desire to have the specifications modified, as has already been done by other railways in Germany and elsewhere. Foreign tin is also granted preferential railway rates, the freight charged to Austria-Hungary and to Bavarian Danube harbors, from the Rhine, and main transhipment centers, being lower for tin imported via Holland and Belgium than for German tin.

Great Britain.—Although exact statistics of production of tin in Great Britain are not available the output was not far from 5200 long tons, as compared with 5052 tons in 1908. That there was a slight increase in production is indicated by a comparison of the output of tin concentrates which amounted to 8289 tons in 1909, as against 8008 tons in 1908. Imports of tin in 1909 were 41,725 tons and exports were 41,413 tons. Imports and exports in 1908 were 47,730 and 42,103 tons, respectively. The table on the opposite page shows the derivation and quantities of tin ore imported for a series of years.

Malaya.—The statistical position of the tin industry of the Federated Malay States (Perak, Negri Sembilan, Selangor and Pahang) was unsatisfactory as compared with 1908. It was thought that the amalgamation into the British Empire of the Siamese Protected States would cause increased returns, but so far the expectations have not been fulfilled. The newly acquired territories do not appear to be rich in minerals and transport difficulties have to be faced, the principal means of communication with the interior or supposed mineral area being by means of rivers which are not always navigable. The sources of the principal rivers are in the mountains which intersect the peninsula and in the dry season there is seldom more than a few feet of water, while a few days' rain causes them to rise to flood levels; the rise and fall have been known to be as much as 20 feet.

IMPORTS OF TIN ORE INTO THE UNITED KINGDOM. (a)

Country.	1906.		1907.		1908.		1909.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Africa:								
Cape of Good Hope	133	14,111	119	14,525	64	5,498	19	1,503
Natal	11	705	254	15,672	2	30	10	610
Nigeria	......	....	75	7,208	464	40,307	230	20,139
Portuguese E. Africa	317	27,109	1,214	64,217	2,076	110,649	8	550
Transvaal	......	....	......	....	......	....	2,621	185,513
Madagascar	......	....	......	....	1	50	......	....
America:								
Canada (Atlantic Ports)	6	346	17	1,290	30	1,195	14	610
United States	9	751	56	3,113	45	2,557	85	3,337
Mexico	......	....	......	....	......	....	2	200
Argentine Republic	74	4,684	254	14,819	576	34,877	32	1,916
Bolivia	......	....	......	....	......	....	14,886	1,037,069
Chile	17,285	1,307,155	15,786	1,350,771	18,437	127,052	3,378	218,370
Peru	267	18,319	420	28,325	1,457	94,541	661	44,399
Asia:								
Bengal	2	20	......	....	......	....	......	....
Burma	1	....	......	....	......	....	2	120
Straits Settlements	86	7,785	13	1,643	......	....	2	150
Australasia:								
New South Wales	599	59,049	46	4,290	37	2,793	140	11,555
Queensland	......	....	11	1,215	1	45	......	....
South Australia	......	....	1	95	......	....	......	5
Tasmania	......	....	......	....	19	1,190	9	546
Victoria	20	1,218	28	2,420	52	4,645	169	11,455
Western Australia	2	82	......	....	19	1,500	......	....
New Zealand	......	....	......	105	......	....	......	....
Europe:								
Austria-Hungary	......	....	......	....	......	24	......	145
Belgium	108	2,780	67	1,785	107	2,594	88	3,149
France	622	40,717	696	29,938	2,346	26,176	853	51,040
Germany	593	16,478	1,182	54,942	193	7,498	314	10,767
Italy	35	660	129	1,814	89	4,362	57	1,985
Netherlands	251	8,650	397	16,081	224	14,267	82	2,968
Norway	......	....	......	....	......	28	1	33
Portugal	17	1,561	5	485	9	458	8	325
Russia	36	795	72	3,051	24	951	97	4,449
Spain	195	12,611	256	18,878	211	11,221	227	11,950
Sweden	3	366	......	....	......	....	......	53
Total	20,672	1,525,926	20,781	1,635,481	25,013	1,640,656	24,082	1,620,815

(a) From the London *Min. Journal.*

Tin mining in Malaya has for the past been carried on principally by Chinese, who even now are responsible for about 85 per cent. of the output, but the alluvial deposits on which they have been mining are fast being depleted and the future of the tin industry will depend upon dredging low-grade ground or hydraulicking, both of which methods are being introduced by European and Australian miners with a certain amount of success. Lode mining is still in its infancy.

An erroneous idea prevails that the Chinese are wealthy and can in consequence rig up the market; but in fact their principal source of finance is the Indian money-lenders (chitties) whose charges for accommodation are so heavy that whatever profits are made in mining or trade are absorbed by them. The European banks do not encourage mining enterprise by accommodation or otherwise. The alleged profits made on mining can, therefore, be considered to benefit the Indian money-lender more than the bona fide miner.

The labor question has not lately given any trouble, for although there was a shortage of 36,000 native miners, it did not tell materially on the output for 1909, but rather increased the output by about 40,000 pikuls (one pikul is equivalent to 133⅓ lb.)

PRODUCTION OF TIN IN THE FEDERATED MALAY STATES.
(In pikuls of 133⅓ lb.)

	1901	1902	1903	1904	1905	1906	1907	1908	1909
Perak	385,060	405,870	436,296	443,507	446,781	435,909	431,386	467,784	459,132
Selangor	302,570	278,360	284,592	300,413	289,867	268,624	273,900	282,540	266,007
Negri Sembilan	75,230	73,520	85,461	84,849	85,133	77,766	75,155	64,221	48,055
Pahang	26,310	23,120	25,317	27,469	34.879	34,488	33,195	39.520	43,144
Total	789,170	780,870	831,666	856,238	856,660	816,787	813,636	854,065	816,338
Metric tons.	47,713	47,211	50,254	51,790	51,793	49,859	48,411	51,654	49,372

The opinion in Malaya is that the future of the tin industry will depend upon the American market and the production of other parts of the world. The price will evidently be regulated to a large extent from New York, inasmuch as the United States consumes upward of 35 per cent. of the world's production of tin. The bogey of fabulous eastern speculators may be exploded for there is not sufficient capital out there to make any firm stand against the interests of the West and the actual producers are living a hand-to-mouth existence, being forced by circumstances to sell their products at the daily market price. From past experience the Chinese will not hold stocks for speculation, and, therefore, there will be no great likelihood of stocks accumulating in the East.

The product of the tin mines is sold in the form of ore to Europeans who have large smelting works at Singapore and Penang and the refined tin is put into the market from there. The Chinese do little or no smelting and in the few instances where smelting is done by them, the ingots have to undergo refining in the Colony. The charge for smelting amounts to about $25 per 2240 lb., the dollar being worth 2s. 4d. The export duty on tin or tin ore works out to about 13 per cent. *ad valorem* and is based according to a sliding scale on the price ruling on day of export. No tin ore may be exported out of the Federated Malay States except to the neighboring Colony and any quantity sent outside is sub ject to a surtax of $30 a pikul in addition to payment of the ordinary duty. It was the imposition of this surtax that prevented the importation of tin ore from Malaya into the United States, where the smeltery of the International Tin Company, at Bayonne, N. J., remains idle, having never been put in operation.

Nigeria.—At the annual meeting of the Nigerian Tin Corporation, Ltd., at London, March 4, 1910, Oliver Wethered, the chairman, stated that this company is interested in one of the most important virgin alluvial tin fields that the world has ever seen. Development has heretofore been delayed by lack of means for economical transport. At present from 28 to 32 days are required to reach the tin fields, but even under this condition the cost of delivering tin at the coast is only about £45 per 2240 ℔. The metal is of very high quality, fetching as a rule from £6 to £8 per ton more than Cornish tin. Completion of the projected railway will lead to great reduction in the cost of production, and will enable the exploitation of the lode mines as well as the alluvial.

According to a recent consular report it has been known with certainty for some time that there are immense alluvial tin deposits both to the north and south of the Benue river, proved by the Niger Company's engineers. The Baro-Kano railway, when completed, will tap the district. The governor of Northern Nigeria, in his last annual report, says of the tin industry in that colony: "The main hope in the development of this promising industry is its situation. With the construction of the railway through Zaria it will be possible to place the mines in close connection with it by means of a road, which also should serve Bautchi province." In 1908 the exportation of tin amounted to 1,163,310 ℔.

Sir Walter Egerton, Governor of Southern Nigeria, in an interview in June, 1910, said: "The question of connecting the tinfields of Northern Nigeria with the Baro-Kano railway at Zaria is under the consideration of the Colonial Office. Everybody believes the tin deposits to be very rich, and if only half the reports concerning them are true, there is more than enough to warrant the expenditure of making a branch to the tinfields of the Province of Bauchi. This would give direct access from the sea at Lagos to the tinfields. The reports show that the tin alluvial is similar to that of the Malay Peninsula."

Siam.—According to a recent U. S. consular report, tin is found throughout the Siamese portion of the Malay peninsula. The island of Junk-Ceylon (Tongkah) furnishes nearly one-half of the tin of the country. The output of tin ore from the island for 1908 was 3713 tons, and that of melted block tin, 2392 tons. Siam's average annual production of tin is estimated at about 5175 tons. English mining companies and the Chinese are the chief workers for tin.

Singkep.—The report of the Singkep Tin Mining Company for the fiscal year ended June 30, 1909, shows an increase of the production and a decrease in the cost of exploitation. The management anticipates that the result of the current year will again be better. The condition of health in general was not quite satisfactory, but also in this respect an improvement is to be noted. The production during the fiscal year was 6872 Dutch-Indian pikuls, against 641 in 1907-8. The tin was sold at an average price of $65.99 per Straits pikul, equal to 94.67 fl. per Dutch-Indian pikul, or 76.64 fl. per 50 kg. (£6 7s. 5d. per cwt.). These figures, in respect to 1907-8, were, respectively, $66.99, 95.78 fl. and 77.54 fl. (£6 9s. 3d.).

The number of contract coolies, which during the fiscal year 1907-8 amounted to 46 per cent. of the entire strength, was only 20 per cent. during the last fiscal year. Some delay was experienced owing to the too abundant rainfall. Work was carried on in 11 quarries, while on three hills the ground has been sluiced off by water under pressure, and on two by simply sluicing with water. Moreover, in three places, tin ore was obtained by means of tunneling. Owing to delay in the delivery and erection of a suction dredge installation, the Ajer Poeteh quarry had still to be worked by means of contract coolies. As in the previous year, the ground in this concession was brought to the surface by means of a ropeway with suspended cable. The exploration of the sea bottom for ore extraction was continued diligently. As the result of extensive boring operations it is now stated that the results of previous borings have been found to be correct, and that the richness in ore is sufficient to warrant the beginning of the exploitation of the ore by means of a dredge.

The following shows the proportion in which the various workings contributed to the production: quarries, 3573 pikuls; hills, 2658; tunneling, 615. The tin ore was delivered to the smelting works of the Straits Trading Company at Singapore, and has been sold as Straits tin through the medium of the agency of the Dutch Trading Company at Singapore. The total production of the mines was valued at 670,998.65 fl. (£55,916 11s. 1d.), and the cost of production, i.e., wages for miners, smelters, and taxes, amounted to 365,045.60 fl. (£30,420 9s. 4d.).

South Africa.—The prospects of tin mining in this Colony are considered to be excellent. After the great setback, resulting from the booming of tin share ventures a year or so ago, the owners of tin properties settled down to real work. Of the several districts the most important is the Waterberg, north of Pretoria, in which the greatest activity at present is that about 20 miles northwest of Potgietersrust. Following is a statement of the producing companies of the Transvaal, and the monthly aggregate output from July, 1908, to end of September, 1909: Zaaiplaats Tin Mining Company, Ltd.; Transvaal Consolidated Land and Exploration Company, Ltd.; South African Tin Mines, Ltd.; Weynek Tin Company, Ltd.; and the Waterberg Tin, Ltd., all in the Waterberg district, and Rooiberg Minerals Development Company, Ltd., in the Rustenberg district. Ore and concentrate shipments in tons were, in 1908: July, 132; August, 140; September, 125; October, 119; November, 114; December, 85. In 1909: January, 80; February, 146; March, 217; April, 257; May, 266; June, 232; July, 167; August, 206; September, 260. The shipments assayed from 28 to 80 per cent. tin, most of them averaging about 70 per cent. Out of the 12 shipments in September last, the lowest assay was 55 per cent., and the highest 72.75 per cent.

Spain.—According to R. S. Lozano in *Boletin* de la Comisión del Mapa geológico de España, 1906, Series 2, Vol. VIII., pp. 11-24, although the Galician tin-ore deposits appear to have been known and more or less worked from time immemorial, the tin-mining industry has never attained adequate importance in that region. Some details are given of the Andorra and Andorra Segunda mines, also the Gloria and Purísima Consepción mines. The extent and number of the lodes have not been definitely determined; assays of crude ore have yielded from 0.96 to 1.86 per cent. of metallic tin. Between 1887 and 1891 the price of tin ore rose to such an extent that various foreign syndicates (English and Dutch among others) were formed to work the Galician deposits. They started with a "grand flourish" of modern methods, but were ultimately obliged to revert to the "antiquated system" in vogue in the district, and, a fall in the price of tin supervening, they suspended operations. Galician deposits are only workable when the price of the metal is high, and the dressing of the ore is subject to serious difficulties, which do not appear yet to have been overcome.

Swaziland.—Tin has been known to exist in this territory for 18 years, but it is only within the last three or four years that it has been produced in any quantity, and to-day the production is confined to one company. The tin belt, as known at present, extends from the Nusuti river in the south to near the Komati river in the north, extending roughly along the eastern side of the Transvaal border, but the eastern limits of the belt are not yet determined. Most of the tin is found on the Mbabanee river and its tributaries and on the higher ground between these waters. Several companies are now engaged in development work. In many of the rivers and flats there are large bodies of alluvial ground carrying tin, and some of the companies are now installing hydraulic appliances. The last returns of the Swaziland Company show the output in the year ending June 30, 1909, to have been 493 tons. The conditions for economic working in Swaziland are said to be especially favorable, water for power and ordinary purposes being abundant and native labor plentiful and cheap. The official statistics of the Colony give the output of tin ore for the fiscal year 1908-9 as 526 tons.

THE TIN MARKETS IN 1909.

New York.—The statistical position of tin, which toward the end of 1908 and during the first quarter of 1909 was an unfavorable one, improved gradually throughout the remainder of the year. The consumption in this country assumed larger proportions, and as shipments from the East did not increase correspondingly, the existing stocks had to be drawn upon. New fields of production were not discovered and the consumers of tin the world over have still in the main to rely for their supplies upon the Straits Settlements and the Dutch colonies in Asia.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1896	13.02	13.44	13.30	13.34	13.54	13.59	13.63	13.49	13.15	12.94	13.09	12.96	13.29
1897	13.44	13.59	13.43	13.34	13.44	13.77	13.89	13.80	13.98	13.88	13.79	13.71	13.67
1898	13.87	14.08	14.38	14.60	14.52	15.22	15.60	16.23	16.03	17.42	18.20	18.30	15.70
1899	22.48	24.20	23.82	24.98	25.76	25.85	29.63	31.53	32.74	31.99	28.51	25.88	25.12
1900	27.07	30.58	32.90	30.90	29.37	30.50	33.10	31.28	29.42	28.54	28.25	26.94	29.90
1901	26.51	26.68	26.03	25.93	27.12	28.60	27.85	26.78	25.31	26.62	26.67	24.36	26.74
1902	23.54	24.07	26.32	27.77	29.85	29.36	28.38	28.23	26.60	26.07	25.68	25.68	26.79
1903	28.23	29.43	30.15	29.81	29.51	28.34	27.68	28.29	26.77	25.92	25.42	27.41	28.09
1904	28.85	28.09	28.32	28.13	27.72	26.32	26.57	27 01	27.78	28.60	29.18	29.292	27.99
1905	29.325	29.262	29.523	30.525	30.049	30.329	31.760	32.866	32.095	32.481	33.443	35.835	31.358
1906	36.390	36.403	36.662	38.900	43.313	39.260	37.275	40.606	40.516	42.852	42.906	42.750	39.819
1907	41.548	42.102	41.313	40.938	43.149	42.120	41.091	37.667	36.689	32.620	30.833	27.925	38.166
1908	27.380	28.978	30.577	31.702	30.015	28.024	29.207	29.942	28.815	29.444	30.348	29.144	29.465
1909	28.060	28.290	28.727	29.445	29.225	29.322	29.125	29.966	30.293	30.475	30.859	32.913	29.725

January and the early part of February witnessed a considerable decline, brought about by bear operators in London, who were on the one hand supported in their policy by the statistical position of the metal, and, on the other hand, by the Banka sale advertised by the Dutch Government. The year opened with prices at about 28¾c. per lb., and this had declined to 27⅝c. by the end of January. The lower quotations created a livelier demand from the American dealers and consumers, and this, coupled with advices of smaller shipments from the Straits, had a sustaining influence on the market. Prices advanced gradually to 29¾c. at the end of March.

Until the middle of August, the market remained rather stationary and did not exhibit any of the violent movements that are characteristic of tin. Thenceforward, the bull leaders in London became more aggressive and succeeded in advancing prices to 30¾c. by the end of September.

During October, the tightening in the money market caused speculative holders in New York to liquidate so that business was transacted at prices below the parity at which tin could be imported. The London market, however, remained firm in view of the favorable statistical position and the good consumptive demand in this country. When the domestic deliveries for the month of October, which showed a remarkable expansion in consumption, became known, and when it became manifest that the consumption of tin in this country would continue at an increasing rate, it was easy for the bull party in London to mark prices up rapidly. By the middle of December 32¾c. was being paid in New York, and at the close of 1909 the metal was quoted at 33¾@34c. ℔.

London.—The market opened firm, three months' warrants touching £134; but a speedy relapse followed on dealers' cheap purchases in eastern markets. This continued for a fortnight or so, the relapse being quickened by the realizations of disappointed speculators, which continued until the end of the month when cash warrants were quoted at £124 7s. 6d. and £126 2s. 6d. for three months. February found the market depressed in sympathy with copper, and holders anxious to liquidate; £123 10s. was accepted for cash warrants. Selling pressure soon ceased; but the underlying conditions were favorable enough to raise prices to £130 2s. 6d. on Feb. 11, and to keep fluctuations within narrow limits during the rest of the month. March statistics disclosed a reduction of 1532 tons in the previous month. A transient improvement in American demand carried the three months' price up to £133 on March 11, but this demand soon slackened.

After touching £133 3s. 9d. for cash warrants and £134 3s. 9d. for three months, on April 7 values improved to £133 7s. 6d. and £134 10s. respectively. The highest was touched on April 20, at £134 10s. for cash, and £135 12s. 6d. for three months. In May the market opened with a downward tendency and £130 2s. 6d. was touched for cash warrants, and £131 for three months', but this attracted American buyers and there was a sharp rally, the three months' price being carried up to £134 15s. In June the market opened quietly, with eastern sellers apparently ready to meet demand, and statistics showing an increase of about 1000 tons. Closing quotations were £132 for cash warrants, and £133 12s. 6d. for three months'.

July opened with a decrease of 1084 tons in the visible supply and improved advices as to the American tinplate industry. The tendency during the month was mostly upward, the highest prices being paid on July 23, when cash warrants changed hands at £135 5s., and three months' at £134 15s. On July 29 the periodical sale of Banka tin in Amsterdam disposed of 2000 tons at the average equivalent of £134 17s. 6d., but without having much effect on the London market. The August statistics proved more favorable than had been expected, and the market opened with an advance of £1 10s. per ton, but promptly relapsed 10s. Closing prices were £139 for cash warrants, and £140 for three months' Disappointment was felt at the September opening by reason of the small decrease of 635 tons in the statistics, and a sharp decline took place, after which there was an improvement, the month closing at £140 10s. and £141 12s. 6d. respectively.

AVERAGE MONTHLY PRICE OF TIN IN LONDON. (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1897	60 .5 .1	61 .4 .3	59.18 .9	59.18 .1	60.17.10	61.16 .6
1898	63 .1 .7	63.15.11	65 .1 .0	65 .3 .0	66 .6 .0	68.15 .0
1899	99.16 .4	108.16 .3	107.16 .8	114 .1 .1	117 .9 .6	117.12 .0
1900	118 .9.11	137.18 .4	142 .0 .0	137.15 .0	135 .1 .8	139. 9 .3
1901	120 .9.10	122 .6.11	116.15 .6	116 .3 .0	123.13 .0	129.16.11
1902	105 .6 .5	114 .4 .9	115.10 .6	125.14 .2	134.13.10	129.12.10
1903	127.12 .6	133 .8 .1	137 .0 .6	136.19 .2	133.12 .0	127.11 .0
1904	130.10 .4	125.13 .6	126 .9 .8	127 .5 .1	125 .7 .2	119.11 .1
1905	131 .5.11	131 .3 .6	134.17 .2	140.11 .8	136.11 .8	138 .3 .6
1906	164.11.10	166 .0.10	166. 1 .2	176.14 .5	192 .6 .4	178 .0 .7
1907	190 .4 .0	191.18 .9	188.17 .6	187 .1 .2	191 .1.10	187.10.11
1908	128 .9 .0	128.14 .1	137.19 .8	143.12.10	135.11 .6	127.12 .2
1909	127 .7 .3	127.15. 3	130 .6 .7	133. 8 .3	131.16.10	133 .4 .0

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
1897	62 .5 .7	61.10 .1	61.12 .8	62.11 .9	62.11 .9	62.10 .0	61. 8 .0
1898	71 .4 .2	73.10 .1	73.15 .7	78.17.10	82 .8 .6	82.10 .7	71 .4 .1
1899	132.13 .1	142 .1 .4	146 .7 .2	144.10 .2	129.16 .0	113. 0 .7	122 .8 .7
1900	142.16.10	140.19 .1	132.13 .9	130.14 .3	127 .3 .8	119.14 .9	133.11 .6
1901	127.19 .9	116 .1 .7	114.10 .6	113 .1 .5	114 .0 .7	108.17.10	118.12 .8
1902	127 .3 .2	126.10 .0	121.10 .7	117.11 .3	115 .2 .3	115.13 .5	120.14 .5
1903	125 .1 .7	127.16.10	120 .9 .6	115.17 .1	116.13 .9	125.15 .0	127 .6 .5
1904	119.18 .6	122 .5 .9	126 .7 .7	130.11 .6	133 .0 .5	133.15 .6	126.14 .8
1905	144 .6 .8	150 .5 .6	146.11 .9	148 .3 .6	152 .5 .3	162.14 .3	143 .1 .8
1906	170.12 .5	180.19.11	184.15 .3	195.15.11	195.15.10	195.19 .9	180.12.11
1907	188 .0 .2	170 .5 .9	166 .6 .6	146 .7 .7	138 .8 .8	125.10 .4	172.12 .9
1908	131 .6.10	134.16 .2	131 .6 .8	133 .8 .8	137 .8 .3	132 .4 .7	133 .2 .6
1909	131.19 .1	135.18 .3	137.14 .6	138.13 .2	140 .0 .3	149 .2 .3	134.15 .6

(a) As reported by Metallgesellschaft, Frankfurt am Main.

October opened inauspiciously with prices lowered to £138 12s. 6d. and £139 15s. At this point eastern sellers withdrew and bears hastened to cover, prices advancing to £140 5s. and £141 7s. 6d. respectively on Oct. 5. Forced realizations carried values down to £137 10s. and £138 17s. 6d. on Oct. 13, from which point they recovered by reason of improved trade demand. Prices touched £139 15s. and £141 5s. on Oct. 18. By this time the financial situation caused uneasiness, and leading operators withdrew their support; a fall of £2 per ton ensued, but was partly recovered as a result of good and steady trade with consumers. November was a busy month throughout, with numerous fluctuations in price, but mainly upward. An initial improvement was due to a decrease of 1935 tons in the monthly statistics. The Banca sale comprised 200 tons which realized the average of £141 10s. The month closed at £142 15s., and £144 12s. 6d. December found the market active and prices advancing, in spite of strenuous bear efforts and in spite of a statistical increase of 1938 tons. American demand was sufficient to outweigh all adverse factors. On Dec. 13, the market opened strong with the three months' price at £150. A reaction to £149 was only temporary, being followed by smart recovery and a further advance to £151 10s., the week closing—after violent fluctuations—at £149 10s. for cash warrants, £150 15s. for three months'. The next week opened with a sensational advance of £4 per ton, and a turnover of about 800 tons. The advance was accomplished by leading operators who took over no large quantity on balance, but were able to work upon the prevailing bullish sentiment which gathered strength and inspired increased activity, in contrast to the quietness which prevailed in other markets with the near approach of the Christmas holidays. This advance held well until the end of the year, prices closing at the highest.

The Detinning of Tin Scrap and Its Commercial Importance.[1]

(By Karl Goldschmidt.)—Since the middle of the last century, the making of tin-plate has constituted one of the main industries of England, the production in the last few years amounting to about 650,000 tons. The tin-plate industry in America began during the last decade. and here also it has obtained a similar importance, the production during the last year amounting to about 500,000 tons. In comparison with this large output, the production of other countries is small; Germany, for instance, produced only 60,000 tons of tin-plate.

Since the beginning of the enlargement of this industry, i. e., since the middle of the last century, the problem of utilizing the tin scrap, which is obtained from the manufacture of tin cans and tin-plate articles in general, has required investigation. This scrap could not be used directly in the open-hearth process on account of its tin contents. The problem was, therefore, to separate the tin from the iron, which appeared to be very simple and to promise reward, as the tin scrap could at that time be obtained gratis from the can factories.

Even as late as the early eighties, when experiments were made on a

[1] Abstract of a paper in *Zeits. f. angew. Chem.*, Jan., 1909.

larger scale at the Goldschmidt works in Berlin, the tin scrap was furnished free of charge and the owners of the tin-plate factories even paid the cost of transportation.

Although the problem seemed to be worth the while, and full of possibilities to the chemist, it required a lifetime of hard labor and perseverance to find an available method in which the products obtained would pay for the necessary reagents and time. The literature on this subject is very extensive; hundreds of patents were obtained, but only a few were brought into use.

It required a half century to surmount the technical difficulties, and to place the detinning industry upon a commercial footing. After this, the industry spread rapidly and soon extended its demand for raw material to other countries. At present, tin scrap is transported from all parts of the world to Germany, where the detinned scrap finds a home market. Three-fourths to four-fifths of the tin scrap in Germany comes from foreign countries and it may seem surprising that such a cheap article could stand high freight rates. Italy sends sardine boxes; Egypt, cigarette boxes; Newfoundland, lobster cans; Norway, fish cans; Switzerland, condensed milk cans; etc. To detin the scrap at these places, would not pay, because the quantity of available scrap is generally insufficient; furthermore, the detinned iron would have to be shipped anyhow to the steel works, and it weighs only 2 per cent. less than the tin scrap. It is, therefore, more practical to transport the tin scrap, rather than the detinned iron; and as the location of the German detinning work is situated on the lower Rhine, it offers special advantages for low freight rates; moreover, scrap yielded a higher price in Germany than in other countries, for instance, England. It is to be regretted that the favorable conditions which have prevailed so far in Germany ceased, as detinned scrap has recently reached a higher market value in England. While formerly the Goldschmidt works were able to obtain better prices for detinned scrap in Germany than in England, about four marks more per 1000 kg., the conditions have been reversed since the latter part of 1906. At that time the difference was one mark per ton. In the beginning of 1907 it amounted to two marks, in the latter part of 1907, three marks, and during 1908, eight to 10 marks.

Although the conditions are again improving slightly in Germany, the difference in the value of detinned scrap is still much lower than in England, and it would be regrettable if the continuation of such conditions should force this industry, which was born in Germany, to be transplanted to a foreign country.

As iron scrap and raw iron are generally cheaper in England than in Germany, the high valuation of detinned scrap by the English steel works in comparison to the German works is to be explained from the fact that the English works buy independently from each other, while the German works have formed a combination and have cut the price. Furthermore, the detinned scrap has lost much of its reputation, as it happened at times that some of the smaller works placed a poorly detinned material on the market.

The detinning industry of Germany treats about 75,000 tons of tin scrap per year. Of this, 50,000 tons are detinned in the Goldschmidt works in Essen, and the balance of 25,000 tons in eight or ten smaller works. Small works are, however, hardly commercial and their troubles are increasing as they have to use the electrolytic process, which is very expensive if carried out on a small scale. Their chances are now very limited, as they have to compete with the chlorine process.

The 75,000 tons of tin scrap which are detinned every year in Germany yield about 1500 tons of tin and tin salts, which represents about 10 per cent. of the total amount consumed in Germany. In other European countries somewhat over 25,000 tons of tin scrap are detinned yearly, and in the United States about 60,000 tons. The total consumption for the world is therefore 160,000 tons of tin scrap, containing 3000 to 3500 tons of tin, which is 3½ per cent. of the total yearly output of tin. When the treatment of old tin cans assumes greater proportions, the output of the detinning works will, of course, greatly increase.

When it is considered that the utilization of old cans has only been started, and that after the technical difficulties have been overcome, and the collection of cans from the dump places and from the households will be effected, the amount of available old cans will reach a value which will exceed all expectations.

Bibliography of Tin in 1909.

Anonymous. "Alluvial Tin in Swaziland." (*So. Afr. Min. Journ.*, Oct. 9, 1909; 1½ pp.)

Anonymous. "British Empire's Tin Output." (*Min. Journ.*, Mar. 20, 1909; 1 p.)

Anonymous. "The Detinning Industry." (*Electrochem. and Met. Ind.*, Feb., 1909; 3 pp.)

Anonymous. "The Detinning Industry." (*Iron and Coal Tr. Rev.*, Mar. 19, 1909; 2 pp.)

Anonymous. "Zaaiplaats Tin Mines." (*So. Afr. Min. Journ.*, Feb. 13, 1909; 1 p.)

Ball, L. C. "The Dolcoath Mine," (*Queensland Govt. Min. Journ.*, Feb. 15, 1909; 3 pp.)

Ball, L. C. "Irvinebank Company's Treatment Works." (*Queensland Govt. Min. Journ.*, July 15, 1909; 2¼ pp.)

Ball, L. C. "King of the Ranges Tin Mine, Watsonville, N. Q." (*Queensland Govt. Min. Journ.*, May 15, 1909; 3½ pp.)

BALL, L. C. ''Some Cornish Mines and Treatment Works.'' (*Queensland Govt. Min. Journ.*, Mar. 15, 1909; 2½ pp.)

BERINGER, J. J. ''Wet Assay of Tin Ores,'' (*Min. Mag.*, Nov., 1909; 2 pp.)

BROWN, E. G. ''Present Position of Bolivian Tin Mines.'' (*Min. Journ.*, Mar. 27, 1909; ½ p.)

COLLINS, W. F. ''Tin Production in the Province of Yunnan, China.'' (*Bull.* 63, I. M. M., Dec. 9, 1909; 14 pp.)

CONDER, HARTWELL, ''Stanley River Tinfield, Tasmania.'' (*Aust. Min. Stand.*, June 16, 1909; 1½ pp.)

CONRAN, R. H. ''Tin Mining in Cornwall.'' (*Aust. Min. and Eng. Rev.*, June 5, 1909; 3 pp.)

DVORKOVITZ, P. ''The Tin-Mining Industry of Cornwall.'' (*Petrol. Rev.*, Aug. 14, 1909; 2 pp.)

ENDTER, AUGUSTO. ''The Tin Mines of Llallagua, Bolivia.'' (*Min. Journ.*, July 10, 1909; 1 p.)

EVERDING. ''Unterlagen zu einer Bergmannischen Lagerstättenbegutachtung im Bolivianischen Zinnerzbezirk.'' (*Glückauf*, Sept. 11, 1909; 11 pp.)

GOLDSCHMIDT, K. ''Detinning of Tinplate Scrap, and Its Economic Importance.'' (*Min. Journ.*, Feb. 20, 1909; ½ p., and *Chem. Engr.*, June, 1909; 4 pp.)

HESS, F. L. ''Tin, Tungsten and Tantalum Deposits of South Dakota.'' (*Bull.* 380-D, U. S. Geol. Surv., 1909; 32 pp.)

HILL, J. H. ''York Tin Mines.'' (*Northwest Min. Journ.*, Mar., 1909; 1 p.)

KNOPF, ADOLPH. ''Geology of the Seward Peninsula Tin Deposits, Alaska.'' (*Bull.* 359, U. S. Geol. Surv., 1909; 67 pp.)

KNOPF, ADOLPH. ''Some Features of the Alaskan Tin Deposits.'' (*Econ. Geol.*, Apr., 1909; 10 pp.)

LAKES, ARTHUR. ''Tin: Its History, Uses and Occurrences.'' (*Min. Wld.*, June 19, 1909; 2 pp.)

LEVY, M. and EWEN, D. ''The Bessemerizing of Hardhead.'' (*Bull.*, I. M. M., May 13, 1909; 9 pp.)

MARKS, E. S. ''Mining in the Malay States.'' (*Min. and Sci. Press*, Jan. 2, 1909; 5 pp.)

MILES, E. T. ''Notes on Tongkah Tin Dredging.'' (*Aust. Min. Stand.*, July 21, 1909; 1 p.)

MILLEN, J. D. ''Mount Bischoff Tin Mining Company, Tasmania.'' (*Aust. Min. Stand.*, Mar. 10 and 17, 1909; 4 pp.)

PARRY, L. ''The Assay of Tin Ore.'' (*Min. Journ., Sept.* 25, 1909; 3½ pp.)

RUMBOLD, WILLIAM R. ''The Origin of the Bolivian Tin Deposits.'' (*Econ. Geol.*, June, 1909; 43 pp.)

SCRIVENOR, J. B. ''Origin of Tin Deposits.'' (*Min. Journ.*, Mar. 6 and 13, 1909; 1½ pp.)

SIMMONS, JESSE, ''Tin in the Black Hills of South Dakota.'' (*Min. Wld.*, May 15, 1909; 1⅓ pp.)

SWINBURNE, U. P. ''The Economic Aspect of the Waterberg Tin Fields.'' (*So. Afr. Min. Journ.*, Aug. 21, 1909; 4½ pp.)

TRENCHARD, H. G. ''Recovery of Tin from Alluvial Deposits.'' (*Aust. Min. Stand.*, Jan. 13, 1909; 1⅓ pp.)

WILLIAMS, G. W. ''Tin Mining and Milling in North Queensland.'' (*Eng. and Min. Journ.*, May 29, 1909; 2⅓ pp.)

TUNGSTEN.

By W. L. Fleming.

The production of tungsten concentrates in the United States in 1909 was 1607 short tons valued at $559,500. This makes 1909 the record year of tungsten production in the United States, the output being nearly 150 tons greater than that of 1907, which was the year of largest production heretofore. The largest yield was from the Boulder county field in Colorado, which contributed 1100 tons, the remainder coming from California and Arizona. It is estimated that about 2500 tons of tungsten ore were used in this country in 1909, about 900 tons being imported. The accompanying table shows the production of tungsten concentrate in the United States for a period of years.

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES. (a)
(In tons of 2000 lb.)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1901	179	$27,720	$155	1906	1,096	443,150	404
1902	184	33,112	180	1907	1,468	715,031	487
1903	292	43,639	149	1908	497	126,281	254
1904	740	184,000	249	1909	1,607	559,500	384
1905	834	257,463	308				

(a) Statistics reported by the U. S. Geological Survey, for 1901-1904.

Prices.—The quotations in the tungsten market are based on the unit of WO_3 in a 60-per cent. ore. At last reports (March 9, 1910), prices fluctuated from $6.50 to $7 per unit for 60-per cent. ore, net ton. For special lots of very high-grade ore a higher price is made. Scheelite is worth 50c. to $1.50 per unit less, the above quotations being for ferberite, wolframite and hübnerite. The market is subject to great fluctuations and quotations cannot be made to hold good for any length of time. Formerly, purchasers demanded 60 per cent. WO_3 in the ore. Now, however, they will take 40-per cent. ore at a lower rate. This allows a closer saving in milling on account of the less exact concentration. The average price for 1909 was about $6 per unit, but during the last quarter of the year it rose to $7 and the market became sensitive, consumption having increased. On the other hand, the miners are preparing for a much larger production. With the present 10-per cent.

duty on foreign ores, the domestic production in 1910 is likely to be considerably larger than in 1909.

Tungsten Mining in the United States.

Arizona.—The only producer of tungsten in Arizona in 1909 was the Williams mine in Mohave county. There are several deposits of tungsten ore in the form of hüonerite at Dragoon and at Gigas, south of Tucson, but they remained unworked during the year. A change of ownership in the Bradford property at Gigas suggested a probable early resumption of work and production of hübnerite concentrates.

California.—Although tungsten occurs at various points in the State, the Atolia region, San Bernardino county, is the only locality where mining is conducted, the entire tungsten production of California in 1909 being made by the Atolia Mining Company, During 1909 the sale of the Weatherbee group of tungsten claims near Atolia was reported. This group has already shown considerable ore and will be further developed. The tungsten fields of the Cima district, San Bernardino county, attracted some attention and work was done upon several claims. The tungsten here occurs as scheelite and wolframite in veins through granite at a distance of from 1 to 2½ miles from a granite contact where copper and silver ores were found and worked about 30 years ago.

Colorado.—The production of Colorado, as heretofore, was entirely from Boulder county, and amounted to 1100 tons of tungsten concentrate. The producing mines of Boulder county may be divided into two groups: (1) Along a narrow belt about nine miles in length following Boulder creek east from Nederland: (2) an area of about one square mile situated about 1½ miles south of Nederland. These two groups comprise the Nederland fields, the most important in the United States both as to extent and richness of the ore. The mineral is locally termed wolframite, but corresponds in composition and properties to the mineral ferberite. The gangue material is always quartz, the vein usually being in a granite gneiss, mica gneiss or porphyry. The Primos Mining and Milling Company, the most important concern in the Boulder district, is now completing a new mill at Nederland.

Montana.—Tungsten was discovered in Goodrich gulch, about eight miles from Twin Bridges, where it occurs in narrow veins in a mica schist and gneiss. Some prospecting is being done, and sorted ores stored on the dumps.

Nevada.—The Melvin group of tungsten claims at Round Mountain were extensively developed during 1909, but no shipments were made A mill is planned at this property.

Tungsten in Foreign Countries.

Austria.—Austria continues to show a gradually decreasing production of tungsten. The latest official figures show 37 metric tons produced in 1908.

Australasia.—The Under-secretary of Mines for Queensland reports the production of 606.5 tons of tungsten concentrates worth £56,348 in 1909, as against 420 tons worth £32.792 in 1908. Tungsten mining is an industry of growing importance in Queensland, now the most important tungsten-producing State of Australia. Activity in this industry began in 1903. The Queensland deposits are numerous and not as yet extensively opened, and it is said that the production can be increased at any time to any extent. At the beginning of 1909, the price for tungsten was £60 per ton, but the year closed with some sales at £140. This caused increased activity in prospecting, especially in the Herberton and Chillagoe fields. Industrial agitation caused enforced idleness of the Irvinebank company's mines and mill at Wolfram, but latterly work has been resumed. Murphy & Lisner's claim at Wolfram Camp shows the best faces of ore in Queensland, and, of newer discoveries, a find made on Martin creek promises to be of more than ordinary importance. Mount Carbine promises to rival Wolfram Camp as a producer in 1910. and the Irvinebank company will erect a mill there to treat its own and custom ores. An excitement was caused by the discovery of tungsten ore near Lake Eacham, but the occurrence is at present confined to one quartz lode about one foot wide. In Victoria, the tungsten claims at Mount Murphy, north of Omeo, were developed and machinery will be installed to treat the ore. Scheelite is reported as being discovered on King island, in a large vein with wood working conditions. New Zealand produced about 68 tons in 1908, worth £6055, making a total of £35,908 since 1853. Tungsten is mined in three places in Otago, New Zealand, where there are milling and concentrating plants. The concentrates are shipped to Germany.

England.—England produced about 376 long tons of tungsten concentrates in 1909. The official production in 1908 was 233 tons, nearly all of which came from Cornwall. The increase over the previous year was chiefly due to larger scale work at South Crofty, which reports 5.38 ℔. of wolframite per ton recovered as a by-product from 59,327 tons of ore.

Portugal.—Portugal continues as a fairly regular producer of tungsten. The production is distributed over several mines in different districts, mostly in the northern part of the country. Official figures give 620 metric tons produced in 1908 as against 612 in 1907. The most prominent event of 1909 was the incorporation in July of the Wolfram Mining and Smelting Company, Ltd. This company took over the well-known Panasqueira mine, the most important in Portugal, and the Cabeço de Piao mine. The Panasqueira is equipped for a production of 200 tons yearly, and the Cabeço de Piao mine is equipped to produce 150 tons. There are ample reserves of ores and the companies can be depended upon to produce about 300 tons regularly per year. The ore mined ranges between 1.7 and 2.2 per cent. tungsten.

Other Countries.—Spain produced 226 metric tons in 1908. No new discoveries or events were reported in 1909, and it may be assumed that production continued at a fairly uniform rate. The production of South Africa comes practically all from Rhodesia, 40 tons having been produced by this country in 1908. The Argentine Republic produced 563,620 kg. of wolframite in the first nine months of 1909. Wolframite was discovered in British India during the year, but no production is reported. Canada has never produced any tungsten, but discoveries have been reported in many places, especially in Halifax county, Nova Scotia, and in British Columbia. France produced 113 metric tons in 1908, which came from the mines of Puy-les-Vignes in the Haute-Vienne and from Montbelleux.

Occurrence of Tungsten Ores, Treatment, New Uses and Analysis.

The tungsten minerals occurring as ores are hübnerite, wolframite, ferberite and scheelite. These minerals, together with their physical and chemical properties, composition, etc., were treated in The Mineral Industry, Vol. XVII.

Contrary to the usual supposition, tungsten is of wide occurrence, but the individual deposits can hardly be said to be large. Frequently, new finds of tungsten are reported, but the workable deposits are few. A mine when discovered may show quite a bunch of tungsten mineral, but in a few feet of work the shoot may suddenly die out or diminish until the only use for the tungsten is as an encouragement to further prospecting. Discoveries of tungsten have been made in the following places, but it is not to be expected that all of these represent workable deposits: Boulder, Gilpin, San Juan, Lake, Ouray, Teller and Dolores counties in Colorado; Arizona; Black Hills in South Dakota; Connecticut; in several localities in Nevada; Stevens county, Wash.; New Mexico; Oregon; Idaho; Montana; North Carolina; San Bernardino county, Cal.; Cornwall, England; Saxony; Germany; Spain; Portugal; Austria-Hungary; Sweden; Bohemia; Nova Scotia; British Columbia; Brazil; Peru; Argentine; Japan; in nearly all the Australian States; New Zealand; Rhodesia; British India; France; in several of the placers in the Yukon district; Bolivia; San Luis Potosi and Sonora, Mexico.

Tungsten ores nearly always occur in quartz veins, cutting rock containing much silica, such as granite and granodiorite. In the *Aust. Min. Stand.,* Charles Bogenreider says: "The distribution of commercial tungsten ore deposits is not widespread, and the greater part of the world's supply comes from few localities. Excluding the few mines of Queensland, New South Wales, Spain, Portugal and America, the tungsten production is extremely slight. At the present time the chief production is confined to the United States, Australia, Spain, Portugal and Argentine. A small amount of concentrates comes annually from mines in other parts of the world, but on account of their situation, they will not yield large returns in the immediate future. Regarding distribution and the nature of the ore deposits, the ore is extremely irregular in distribution, occurring in bunches, sometimes of great richness, occasionally carrying several hundred pounds of nearly pure tungsten ore, but only in spots assaying above the 3 or 5 per cent. which is necessary to make the mine pay. It is found that near the contact zone of the granites with the slate or other country rock, the ore is usually richer, and that here the gangue often becomes altered into pegmatitic masses. Some interesting results have been obtained from the careful study of tungsten ore lodes with reference to their origin. Most of the regions are of great geological complexity, metamorphic rocks and granite being traversed by diorite, dolomite, andesite, quartz porphyry, aplite, etc. Everything indicates that the tungsten ore deposits have been recently formed, that little erosion has taken place since their formation, and that the source of the metalliferous solutions is not deep seated. From a study of all the conditions, one may conclude that the history of the majority of the deposits has been, first, a faulting of the rock, then the percolation of acid water through them, producing an alteration of the minerals into greisen, etc., and causing the extraction of tungsten, principally from andesite, diabase and eurite, and finally an uprush of superheated acid water, accompanied by the deposition of quartz, wolframite, hübnerite, ferberite, scheelite, etc. The variations in the amount and character of the tungsten ores are due partly to the variations in supply, and partly to the influence of the neighboring rock."

Ore Treatment.—Successful wet concentration of tungsten is difficult, although mills claim to save from 70 to 90 per cent. In 1909 the American Smelting and Refining Company made an appropriation for experiments in tungsten ore dressing at the Globe plant near Denver. The usual basis of quotations on tungsten ores is a grade containing 60 per cent. WO_3 and when the product falls far short of this content it is difficult to sell even at a reduced quotation. Of late, however, buyers are taking the Colorado product on a 40-per cent. basis, thereby allowing the mills to send a great deal of the quartz which carries slime into the finished product and avoiding a heavy loss. Wolframite is slightly magnetic and magnetic concentration has been tried with success in some cases. This process will not apply to scheelite.

Wet concentration is the means generally employed. In this connection tungsten ores are difficult to work on account of the fact that the minerals are relatively soft and slime badly. In California, a scheelite and quartz ore is treated in a mill containing the following equipment: Blake crusher, 6-ft. Huntington mill and 6-ft. Frue vanners. It is claimed that this process makes less slime than would be generated in crushing with a stamp battery, and in these mills no attempt is made to recover the slime. The operators claim to save 70 per cent. of the tungsten content of the ore. In Australia the equipment is rock breakers, screens, stamps or rolls and ball mills, jigs, Wilfley and Card tables, Buss tables, Lührig or Frue vanners and slime tables. These mills make a product containing about 50 per cent. WO_3 which is shipped to England for further treatment. At Wolfram Camp, Queensland, rock breakers followed by Cornish rolls, Krupp tables and Frue vanners are used. The separation in the Boulder county field, Colo., is difficult, as the tungsten mineral is there scattered through and intimately mixed in fine particles with the gangue (quartz). At the Wolf Tongue mill, the ore passes over a 2-in. grizzly, through a 7x10 Blake crusher to a 20-stamp battery (the stamps of which weigh 1000 lb. and make ninety 6-in. drops per minute), through a 20-mesh, long-shot screen, thence by launder to a hydraulic classifier which makes three products. The coarse goes to two No. 5 Wilfley tables, the middlings to a No. 3 Wilfley, and the slimes to two other No. 3 Wilfleys. Tables Nos. 1 and 2 (the No. 5 tables), make four products: a finished concentrate, a first middling which is returned to the head of the table, a second middling which goes to the Wilfley slimers, and a tailing. Tables Nos. 3 and 4 make two products—a finished concentrate and a tailing for the slimers. There are five 12-ft. Wilfley slimers. The slimes from the five concentrating tables are brought together in a tank and distributed to four of the slimers, each of which makes three products—a finished concentrate, a finishing tailing, and a middling taken from the four last panels. The middling goes to the fifth slimer where two products are made—a concentrate and a tailing. The mill concentrates 15 into 1 and treats 25 tons in 12 hours.

Manufacture and Uses.—The common uses of tungsten were detailed in THE MINERAL INDUSTRY, Vol. XVII. During 1909 considerable interest was manifested in the utilization of tungsten in manufactures. The Chemische Fabrik, Fuerth, Bavaria, now makes a ferro-tungsten powder which is of high purity and alloys readily with the metal, a much better product being made with greater ease and with less waste than with the use of metallic tungsten or ferro-tungsten in lumps. The research laboratory of the General Electric Company, at Schenectady, N. Y., has succeeded in producing pure tungsten which is so ductile that it has been drawn into the finest wire, and which possesses extraordinary tensile strength. The outcome of this work should be important in the manufacture of the tungsten lamp, as the fragilty of the filament has been one of the most serious drawbacks to the introduction of this lamp. Tungsten salts are used in fireproofing cloth for curtains, draperies, etc.; in weighing silks; in glass making; as a mordant in dyeing; and for other purposes.

New Method of Analysis.—The determination of small quantities of tungstic acid by common methods is difficult, and involves much time and labor. Three methods are in common use: (1) the aqua regia method; (2) the aqua regia method with previous treatment with hydrofluoric acid; (3) fusion with alkalies and subsequent determination with mercurous nitrate. H. W. Hutchin and F. J. Tonks have evolved a scheme which is more speedy and accurate: their analysis is, however, not adapted to scheelite ores. The charge taken may be five grams or more, only four-fifths of the solution being used for the actual assay. The charge is digested in a 4-in. porcelain dish with 20 cc. of a 25-per cent. solution of caustic soda (free from chloride) on a water bath for 30 to 45 minutes. The assay is next diluted, a little sodium peroxide added to oxidize any decomposition products of sulphides, then transferred to a $\frac{1}{4}$-liter flask and diluted to 250 cc.; 200 cc. of a filtered portion are first acidified with nitric acid, then made alkaline with ammonia. The assay is brought to the boiling point, filtered and washed. The filtrate is made slightly acid with dilute nitric acid, and mercurous nitrate solution added in excess, followed by a few drops of dilute ammonia. On warming and stirring, the precipitate settles readily. After filtering and washing the precipitate with weak mercurous nitrate solution, the paper and precipitates are ignited together in a porcelain crucible; or, if the ore is free from arsenic, in a platinum crucible. Weigh as tungstic acid. With a charge of 5.6 grams, the weight in milligrams divided by 2, give pounds of WO_3 per long ton. To prepare the mercurous nitrate solution, from 2 to 3 oz. of mercury are digested on a hot plate for $1\frac{1}{2}$ hours in a large beaker or flask (the hot plate being near the boiling point) with 25 cc. of nitric acid (sp.gr. 1.4) and 77 cc. of water and left on the hot plate over night. The extract diluted to about 400 cc. will give a saturated solution with a minimum of free acid; 20 cc. are sufficient for most assays. This method is suited to either high- or low-grade ores.

Bibliography of Vanadium in 1909.

Anonymous. "Occurrence and Utilization of Tungsten Ores, Part II." (*Bull.* Imperial Inst., Vol. VII., No. 3, 1909; 10 pp.)

Baskerville, C. "The Rare Metals—Tungsten." (*Eng. and Min. Journ.*, Jan. 23, 1909; 1 p.)

Bronckart, F. "Le Wolfram en Portugal." (*Annales*, Soc. Geol. de Belgique, Oct. 15, 1909; 10½ pp.)

George, R. D. "Tungsten Industry of Boulder County, Colo., in 1908." (*Eng. and Min. Journ.*, May 22, 1909; ½ p.)

George, R. D. "The Main Tungsten Area of Boulder County, Colo." (*Proc.* Colo. Sci. Soc., Aug., 1909; 38 pp.)

Hills, Victor G. "Tungsten Mining and Milling." (*Proc.* Colo. Sci. Soc., Apr., 1909; 20 pp.)

Hess, F. L. "Note on a Wolframite Deposit in the Whetstone Mountains, Arizona." (*Bull.* 380-D, U. S. Geol. Surv., 1909; 2 pp.)

Hess, F. L. "Tin, Tantalum and Tungsten Deposits in South Dakota." (*Bull.* 380-D, U. S. Geol. Surv., 1909; 32 pp.)

Hutchin, H. W., and Tonks, F. J. "The Determination of Tungstic Acid in Low-grade Wolfram Ores." (*Trans.* I. M. M., May 13, 1909; 11 pp.)

Surr, Gordon. "Tungsten Deposits and Surface Enrichment." (*Min. Wld.*, Jan. 2, 1909; 1¾ pp.)

Van Wagenen, H. R. "Tungsten in Colorado." (*Quart.* Colo. Sch. Mines, Apr., 1909; 36 pp.)

Von Keyserling. "Wolfram Deposits in the Argentine Republic." (*Zeit. f. Prak. Geol.* XVII, 156.)

Walker, T. L. "Report on the Tungsten Ores of Canada." (Canada Dept. of Mines, Mines Branch, 1909; 56 pp.)

Williams, J. H. "Tungsten Deposits Near Ivanspah, San Bernardino, County." (*Los Angeles Min. Rev.*, Oct. 30, 1909; 2 pp.)

Wood, Henry E. "Notes on the Magnetic Separation of Tungsten Minerals." (*Proc.* Colo. Sci. Soc., Apr., 1909; 5 pp.)

VANADIUM.

The consumption of vanadium as an ingredient in the manufacture of special steels appears to be on the increase as the properties and influence of the metal are coming to be better understood, and as the metallurgical difficulties in the preparation of satisfactory vanadium and ferro-vanadium are being overcome. At present the principal commercial sources of vanadium are the patronite deposits at Minasragra, Cerro de Pasco, Peru, which are controlled by the American Vanadium Company of Pittsburg, Penn., and the deposits of roscoelite and carnotite in southwestern Colorado, owned by the Vanadium Alloys Company, the American Vanadium Company, and other individuals.

The number of minerals which contain vanadium is very large, but in addition to those mentioned in the preceding paragraph, the only other one that is of commercial importance, is vanadinite, which has been found associated with the oxidized ores of lead and copper in various parts of the West. Another mineral, descloizite, has been found in various districts of Mexico and elsewhere, and small quantities of it have been consumed.

The producers of vanadium ores in the United States are the Vanadium Alloys Company, of Newmire, Colo., the Dolores Refining Company, of Cedar, Colo., and the United States Vanadium Company, of Telluride, Colo. The patronite found in Peru is roasted at the mine into the form of a mixed oxide and sulphite of vanadium, which is then shipped to the works of the American Vanadium Company, at Bridgeville, Penn. It is believed that the present sources of vanadium in this country are not sufficient to supply the demand of steel manufacturers, but the Peruvian deposits are said to be ample for many years. The occurrence of the vanadium ores in Colorado and the methods employed for extracting the metal have been fully described in Vols. XVI and XVII of The Mineral Industry. More recently the Peruvian deposits have been described by D. Foster Hewett in *Bull.* No. 27, 1909, of the American Institute of Mining Engineers, and the deposits in Colorado have been described in detail by Herman Fleck, in the *Quarterly* of the Colorado School of Mines, for January, 1909. The principal manufacturers of ferro-vanadium are the Electrometallurgical Company of America, of New York, and the Primos Chemical Company, of Primos, Pennsylvania.

Mexico. (By Kirby Thomas.)—The element vanadium was discovered in Mexico in 1801 by Del Rio in ore from Zimapan. In recent years several attempts at commercial production of vanadium ores have been made. A shipment to France of 11 tons of descloizite was made about 1905 from Charcas, San Luis Potosi. Vanadinite and descloizite are found at El Doctor mine, Queratero, in the Zimapan district of Hidalgo, and at Poso, Guanajuato. From the latter district a small amount of descloizite has been shipped. A deposit near Zacatecas yields mimetite, a complex lead mineral, with about 2.5 per cent. of vanadium. Negotiations for the exploitation of this deposit are now under way.

Wet Assay for Vanadium Ores.—A rapid method of determining vanadium in ores is given by P. y. Alvarez in *Chem. Ztg.* From 0.5 to 1 gram of the finely ground ore is fused with seven or eight times its weight of pure, dry sodium peroxide, keeping the mixture at a red heat for about 20 min. After extraction of the mass with boiling water, the alkaline filtrate is acidified with sulphuric acid, alcohol added, and without filtering a current of sulphurous acid is passed through until the solution is nearly saturated. This is necessary to effect complete reduction, especially if arsenic is present. If necessary the blue liquid is filtered, and the alcohol and sulphurous acid removed by heating and passing a current of carbon dioxide through the solution. At this stage, if arsenic is present the solution is treated with sulphuretted hydrogen, the arsenic sulphide filtered off and the excess of sulphuretted hydrogen expelled by boiling. The vanadium solution, which should be of approximately 1-per cent. strength, is titrated with potassium permanganate. As a check, a solution of ammonium metavanadate from which the ammonia has been expelled by caustic soda, is treated under precisely similar conditions with regard to concentration, acidity and temperature. The oxidation of the hypovanadic acid to vanadic acid is considered complete when the change from the blue to pink color is permanent.

Bibliography of Vanadium in 1909.

Anonymous. "Vanadium, Its Occurrence, Preparation and Uses." (*Bull.* Imperial Inst., Vol. VII, No. 4, 1909; 11 pp.)

Alvarez, Pinerda Y. "Schnellmethode zur Bestimmung des Vanadins in Erzen und Vanadinhaltigen Technischen Produkten." (*Chem. Ztg.*, Oct. 30, 1909; ½ p.)

Auchy, George. "Further Remarks on Vanadium and Its Estimation." (*Journ. Ind. and Eng. Chem.*, July, 1909; 4 pp.)

Baskerville, Charles. "The Rare Metals, Part IX: Vanadium." (*Eng. and Min. Journ.*, Mar. 6, 1909; 1 p.)

Bleecker, W. F. "A Critical Discussion of the Analytical Methods of Estimating Vanadium." (*West. Chem. and Met.*, Feb., 1909; 9 pp.)

Campbell, E. D. and Griffin, C. E. "On the Volumetric Estimation of Uranium and Vanadium." (*Journ. Ind. and Eng. Chem.*, Sept., 1909; 4 pp.)

Ede, H. E. "Occurrences and Use of Vanadium." (*Min. Journ.*, Sept. 25, 1909; 1¼ pp.)

Fleck, H. "Welfare of Colorado's Rare Metal Industry." (*Bull.*, Colo. School of Mines, Jan., 1909; 9 pp.)

Fleck, H. "Rare Metals: Uranium and Vanadium Deposits in Colorado." (*Quart.* Colo. School of Mines, Jan., 1909; 51 pp.)

Haynes, J. H. "Uranium and Vanadium Metallurgy." (*Mines and Minerals*, Oct., 1909; 1¾ pp.)

Hewett, D. Foster. "Vanadium Deposits in Peru." (*Trans.* A. I. M. E., Feb. and Oct., 1909; 28½ pp.)

Ross, G. M. "Action of Sulphur Monochlorides on Uranium and Vanadium." (*Bull.*, Colo. School of Mines, May, 1909; 10 pp.)

Watts, H. F. "A Method for the Determination of Vanadium." (*West. Chem. and Met.*, Nov., 1909; 2½ pp.)

Weckwarth, E. "The Occurrence of the Rare Metals in Peru." (*Min. Journ.*, Apr. 24, 1909; ½ p.)

ZINC.

By W. R. Ingalls.

The production of spelter in 1909 exceeded the highest figure previously on record. The deliveries for consumption increased even more than the production, inasmuch as there were larger imports of foreign spelter than is usually the case, and there was a diminution of stocks in the hands of the smelters. The demand for consumption, especially in ths brass and galvanizing trades, was excellent. The business in sheet zinc improved materially, but not perhaps to as large an extent as in the other branches.

During the first half of 1909 the zinc industry was greatly disturbed by the fight over the tariff question, which was finally won by the producers of ore. Under the new tariff zinc ore (formerly free of duty) is subject to a graduated schedule, rising to 1c. per lb. on the zinc content of ore assaying 30 per cent. zinc. The zinc smelters are not interested in ore of any lower grade than that, and consequently in their case the maximum rate of duty is of general application.[1]

The imposition of this duty coming contemporaneously with a buoyant feeling in nearly all lines of business and an improved demand for spelter led to an advance in price to a high level, which indeed made it possible to resume the importation of Mexican ore in spite of the duty.

I. PRODUCTION OF SPELTER IN THE UNITED STATES.

States.	1901	1902	1903	1904	1905	1906	1907	1908	1909
Colorado	....	....	877	4,906	6,599	6,260	5,200	3,079	6,115
Illinois (*a*)	44,896	49,672	49,526	47,607	45,357	48,238	56,103	50,244	75,229
Kansas	74,270	87,321	87,406	103,721	114,948	129,741	133,561	99,136	103,390
Missouri	13,083	10,548	9,894	12,056	11,800	11,088	11,594	10.196	8,418
Oklahoma	....	....	....	....	....	....	5,094	14,867	28,840
South and East (*b*)	8,603	10,698	10,799	13,513	23,044	30,167	38,060	32,989	44,470
Total tons of 2000 lb	140,822	158,239	158,502	181,803	201,748	225,494	249,612	210,511	266,462
Total tons of 2240 lb	125,734	141,283	141,520	162,324	180,132	201,343	222,868	187,776	237,913
Total metric tons	127,751	143,552	143,792	164,921	183,014	204,548	226,398	190,933	241,730

(*a*) Up to 1903, inclusive, includes also the production of Indiana. (*b*) New Jersey, Pennsylvania and Virginia, and (since 1903) West Virginia.

Previous to the enactment of the new tariff many of the smelters imported large quantities of ore and also stocked up from domestic

[1] There is considerable uncertainty as to important provisions of the Payne-Aldrich tariff, and Treasury rulings have already been necessary. Possibly there will be litigation. The subject was discussed in *Eng. and Min. Journ.*, Oct. 30 and Nov. 13, 1909.

sources, so that while the quotational margin for 1909 does not show well the rise in the price for the metal was highly profitable to some of the smelters. The zinc smelting industry, however, was by no means a bed of roses for all interests. The immediate effect of the rise in spelter was to stimulate developments to the west of the Rocky mountains, and there is every prospect of a greatly increased supply of ore from that region. In particular it seems as if the zinc mines of Butte, Mont., would become of great importance. Shipments from Butte in 1909 were considerable, and the construction of two large mills, now in progress, will greatly increase the supply in the near future. The Butte ore assays about 24 per cent. zinc and can readily be concentrated to 50 per cent., with but little iron, and occurring in large bodies which can be mined and milled at $4@4.50 per ton, with a $7 freight rate on the concentrate, the mines can produce profitably on a basis of 5c. spelter, or less. The very low freight rates quoted by the railways, considering the long haul, promote the development of zinc mines in the far West. During 1909 a considerable tonnage of calamine was shipped from the new mines in southwestern Nevada, which was hauled to Kansas smelteries at $8 per ton. This ore assayed about 45 per cent. zinc.

In the East there was an increased production in Wisconsin and Oklahoma. The ore deposits of the latter State appear to be of importance, but development is retarded by the absurdly extortionate demands of the owners of the land and the lack of expert knowledge and efficient means to mill the peculiarly complex ore. One drawback hangs upon the other. So long as greedy land- or lease-owners exact an outrageous scale of royalty, the big companies that are able to solve the mining and milling difficulties will not go into the district.

Anyway, the result of 1909 made it clear that the shortage of zinc ore in this country is not so pronounced as we thought during the pessimistic days of depression following the panic. The demand for a tariff on foreign ore was pressed at a period when spelter was low along with other metals, with which it would certainly have appreciated upon the revival in business. The tariff doubtless contributed to a jacking up of the price to an inordinate level, but as new supplies of ore are developed we are likely to see a recession to what would have been the normal level without any tariff. The latter will, however, excite local irritations, as for example, to those smelters who are short of gas and miss the Mexican calamine that does not require roasting.

The gas question is in fact becoming very serious in Kansas, especially at Iola. There is still an abundant supply of gas in Oklahoma, and we shall look for a gradual transference of a part of the smelting industry from Kansas to that State, which is already indicated by the statistics. The occurrence of zinc ore and natural gas in such proximity as in Oklahoma emphasizes the shortsightedness that prevents both resources from being utilized to the best advantage. It is, however, now more certain than ever that the future locus of the zinc smelting industry of the West will be in the coalfields of Illinois.

Smelting Capacity.—An accompanying table gives the number of furnaces and retorts of the active zinc-smelting works of the United States at the end of 1909. The list includes two or three works that were not in operation in 1909 and will soon disappear doubtless from the active list.

II. PRODUCTION OF ZINC IN EUROPE AND AMERICA. (*a*)
(In metric tons.)

Year.	Austria.	Belgium.	France.	Germany.	Holland.	Italy.	Russia.	Spain.	United Kingdom.	United States.	Totals
1896..	6,888	113,361	45,585	153,082	4,770	*Nil.*	6,257	6,133	25,278	70,432	421,786
1897..	6,236	116,067	38,067	150,739	6,600	250	5,868	6,244	23,805	91,070	444,946
1898..	7,302	119,067	37,155	154,867	6,700	250	5,664	6,031	28,387	103,514	468,937
1899..	7,192	122,843	39,274	153,155	6,235	251	6,331	6,184	32,322	117,644	491,331
1900..	6 742	119,315	36,305	155,799	6,845	547	5,963	5,611	30,207	111,794	465,438
1901..	7,558	127,170	37,600	166,283	7,855	511	6,090	5,354	29,877	127,751	516,049
1902..	8,309	124,780	36,300	174,927	9,910	485	8,280	5,569	40,244	143,552	552,356
1903..	8,949	131,740	37,416	182,548	11,515	126	9,901	5,134	44,110	143,792	569,971
1904..	9,159	137,323	41,600	193,058	12,895	189	10,607	5,887	46,218	164,921	621,857
1905..	9,204	142,555	43,200	198,208	13,550	5	7,520	6,184	50,125	183,014	653,565
1906..	10,711	148,035	46,536	205,691	14,650	69	9,610	6,209	52,587	204,548	698,646
1907..	11,208	154,492	(*c*)49,733	208,195	14 990	88	10,409	(*c*)6,000	55,595	226,398	737,108
1908..	12,770	161,940	47,880	216,490	17,257	(*d*)100	9,960	6,357	54,473	190,933	718,160
1909..	12,638	167,100	(*c*)49,718	219,766	19,548	(*b*)	7,949	(*c*)6,400	59,350	241,730	784,199

(*a*) From the official statistics of the various Governments except 1906 to 1909 inclusive, for which years the figures reported to Henry R. Merton & Co. have been used where the official statistics were unavailable. In addition to the production reported in this table, Australia produced 286 long tons in 1903, 299 in 1904, 544 in 1905, 1008 in 1906, 980 in 1907, and 1086 in 1908. (*b*) Included in Austria. (*c*) An approximate separation of the total which is reported for "France and Spain." (*d*) Estimated.

There was but little increase in the smelting capacity in 1909, the capacity being already in excess of the immediate requirements and conditions being unfavorable to lead any of the smelters to make provisions for the future. Such additions as were made in 1909 were chiefly for the completion of new plants of which the construction had been begun in previous years. Thus, at Depue, Ill., two blocks, comprising 1520 retorts, were added, and at Danville, Ill., one block, comprising 900 retorts; at Caney, Kan., half a block, comprising 288 retorts, was added. The Lanyon-Starr Company, of Bartlesville, Okla., has two blocks, comprising 1152 retorts, which have never been fired.

Consumption.—The production of virgin spelter in 1909 was 266,462 tons, against 210,511 in 1908; of spelter derived from scrap, dross and other waste products 14,568, against 12,150; total production, 281,030 in 1909 against 222,661 in 1908. These statistics require considerable explanation. The production of the ore smelters includes some metal derived from dross, the amount of which cannot easily be reported separately. The production credited to the dross and scrap smelters is doubtless incomplete, owing to small concerns that escape enumeration. Moreover, it is somewhat uncertain where to draw the line in the statistical accounting of their production. Some is resmelted; some is merely remelted. When such spelter is marketed in slabs it plays the same part in the trade as does virgin spelter. In fact there is some spelter reproduced from waste products that is of superior quality as compared with virgin prime western. Besides the zinc that returns to the market in this way, a good deal of scrap zinc is utilized directly in the manufacture of such chemical products as zinc chloride, zinc sulphate and lithophone. This is not statistically accounted.

III. ZINC SMELTING CAPACITY OF THE UNITED STATES.

Name.	Location.	Furnaces.	Retorts.
American Zinc, Lead and Smelting Co.	Deering, Kan.	6	3,840
American Zinc, Lead and Smelting Co.	Caney, Kan.	6	3,648
Bartlesville Zinc Co.	Bartleville, Okla.	6	3,456
Bertha Mineral Co.	Pulaski, Va.	10	1,400
Chanute Zinc Co.	Chanute, Kan.	4	1,280
Cockerill Zinc Co.	Altoona, Kan.	6	3,840
Cockerill Zinc Co.	Bruce, Kan.	4	896
Cockerill Zinc Co.	Gas City, Kan.	4	2,560
Cockerill Zinc Co.	La Harpe, Kan.	3	1,856
Cockerill Zinc Co.	Nevada, Mo.	3	648
Cockerill Zinc Co.	Rich Hill, Mo.	....	....
Edgar Zinc Co.	St. Louis, Mo.	9	2,000
Edgar Zinc Co.	Cherryvale, Kan.	24	4,800
Granby Mining and Smelting Co.	Neodesha, Kan.	6	3,840
Grasselli Chemical Co.	Clarksburg, W. Va.	10	5,760
Hegeler Bros.	Danville, Ill.	2	1,800
Illinois Zinc Co.	Peru, Ill.	7	4,640
Lanyon-Starr Smelting Co.	Bartlesville, Okla.	6	3,456
Lanyon Zinc Co.	Iola-La Harpe, Kan.	15	9,740
Matthiessen & Hegeler	Lasalle, Ill.	5	4,380
Mineral Point Zinc Co.	Depue, Ill.	5	3,920
National Zinc Co.	Bartlesville, Okla.	4	2,432
New Jersey Zinc Co.	Palmerton, Penn. Bethlehem, Penn.	30	5,104
Pittsburg Zinc Co.	Pittsburg, Kan.	4	910
Prime Western Spelter Co.	Gas, Kan.	14	8,584
Sandoval Zinc Co.	Sandoval, Ill.	4	896
United States Zinc Co.	Pueblo, Colo.	6	1,440
United Zinc and Chemical Co.	Iola, Kan.	6	2,784
United Zinc and Chemical Co.	Springfield, Ill.	2	640
Totals		211	90,550

In previous years we have reported the domestic consumption of spelter according to purpose upon the basis of reports made by the consumers. These reports have covered the major part of the consumption. It has not been possible to secure reports from some consumers of zinc for brass-making and for miscellaneous purposes, but with nearly complete reports for galvanizing and sheet zinc and assuming that consumption was equal to deliveries it was possible to supply missing returns by difference. For 1908 and 1909, however, this was impossible, the consumption in those years having been materially less than the deliveries, as is well known. Our reports for consumption in 1908 and 1909 are consequently to be regarded more in the nature of an estimate than have been those of previous years. As an indication of the basis of estimate, however, we may say that the returns actually received for 1909 aggregated 134,607 tons. Our estimate of consumption is given in accompanying tables.

IV. EXPORTS OF ZINC ORE AND ZINC OXIDE FROM THE UNITED STATES. (a)

Year.	Ore.			Oxide.		
	Short tons.	Value.	Value per ton.	Short tons.	Value.	Value per ton.
1897	9,251	$211,350	$22.85	1,859	$104,140	$56.02
1898	11,782	299,970	25.50	3,925	252,194	64.25
1899	28,221	725,944	25.90	5,343	366,598	68.61
1900	42,062	1,134,663	26.98	5,656	496,380	87.76
1901	44,146	1,167,684	26.45	4,561	393,259	86.22
1902	55,733	1,449,104	26.00	5,358	433,722	80.93
1903	39,411	987,000	25.04	7,215	578,215	80.14
1904	35,911	905,782	25.22	8,157	628,494	77.05
1905	30,946	848,451	27.41	11,280	810,203	71.83
1906	27,720	733,300	26.45	15,578	1,149,297	73.78
1907	20,352	579,490	28.47	13,256	1,069,924	80.71
1908	26,108	877,745	33.60	12,008	845,070	70.37
1909	12,456	412,300	33.10	14,846	1,026,377	69.14

(a) In addition to the exports of ore, 15,887 short tons of zinc dross (galvanizers' waste) were exported in 1906, 9593 short tons in 1907, 8405 short tons in 1908 and 7069 short tons in 1909.

V. EXPORTS OF DOMESTIC SPELTER FROM THE UNITED STATES. (a)

Year.	Plates, Sheets, Pigs and Bars.		Wares.	Total Value.
	Short Tons.	Value.	Value.	
1896	10,150	$1,013,620	$51,001	$1,112,029
1897	14,245	1,356,538	71,021	1,743,049
1898	10,499	1,033,959	138,165	1,724,188
1899	6,755	742,521	143.232	1,978,295
1900	22,411	2,217,963	99,288	2,317,251
1901	3,390	228,906	82,046	310,952
1902	3,237	300,557	114,197	414,754
1903	1,521	163.379	71,354	234,733
1904	10,073	1,094,490	117,957	1,212,447
1905	5,516	682,254	159,995	842,249
1906	4,670	583,526	204,269	787,795
1907	563	75,526	186,283	261,397
1908	2,640	250,254	88,485	338,739
1909	2,566	263 010	69,751	232,761

(a) There is also a comparatively insignificant re-export of foreign-made spelter and zinc wares.

The statistics for consumption both in 1908 and 1909 are probably under the true totals, but even after making allowance for the tendency of statistics that have to be collected from a multitude of small consumers to fail by omissions, there is nevertheless no doubt that in 1909 the actual consumption fell short of the deliveries by an even greater amount than in 1908. This means that at the end of each year the galvanizers, brass-makers, etc., had supplies to large amount in their yards and possibly spelter may also have been in warehouse for speculative accounts besides that which was carried at the smelteries. It is especially the time required for the digestion of these invisible supplies that accounts for the low range of spelter price during the last two years, relieved only by the fitful rise in 1909 when it was feared that the Payne tariff was going to reduce ore supply. The actual consumption of spelter increased largely, the amount in 1909 being the largest on record, but the production was too big.

VI. IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES.
(In pounds.)

Year.	Sheets. Blocks, Pigs and Old.		Manufactures	Total Value.	Oxide.	
	Amount.	Value.			Dry.	In Oil.
1896	856,044	$25,904	$15,728	$41,632	4,572,781	311,023
1897	2,557.341	95,883	19,431	115,314	5,564,753	502,357
1898	2,742,357	109,624	13,448	123,072	3,342,235	27,050
1899	2,985,463	151,956	14,800	166,756	3,012,709	41,699
1900	2,013,196	97,772	36,836	134,608	2,618,808	38,706
1901	775,881	30,920	42,643	73,563	3,199,778	128,198
1902	1,238,091	46,713	37,191	83,904	3,271,385	163,081
1903	728,614	30,900	18,938	49,838	3,487,042	166,034
1904	933,474	44,326	11,918	56,244	2,585,661	224,244
1905	1,042,081	51,052	12,390	63,442	3,436,367	342,944
1906	4,407,481	253,310	17,385	270,695	4,191,476	292.538
1907	3,555,890	210,322	16,282	226,604	5,311,318	362,418
1908	1,762,627	85,885	7,474	93,359	4,635,101	210,166
1909	19,340,029	826,588	19,176	845,764	6,119,328	535,024

VII. DELIVERIES OF SPELTER IN THE UNITED STATES.
(In tons of 2000 lb.)

	1905	1906	1907	1908	1909
Stock, Jan. 1	6,500	4,000	4,550	32,883	25,000
Production	201,748	225,494	249,612	210,511	266,462
Imports	521	2,203	1,778	881	9,670
Total supply	208,769	231,697	255,940	244,275	301,132
Exports	5,515	4,670	563	2,640	2.566
Stock, Dec. 31	4,000	4,550	32,883	25,000	11,500
Deliveries	199,254	222,477	222,494	216,635	287,066

Production of Zinc Ore.—The production of zinc ore in North America in 1909 is given in the accompanying table. The figures are compiled from reports of ore receipts by the smelters and oxide manufacturers, except in the case of New Jersey, and consequently represent closely the production of the mines. The figures for New Jersey represent mine production. This ore, averaging about 20 per cent. zinc, is separated primarily into willemite and franklinite. The former is used for the manufacture of spelter here and abroad. The latter is employed for the manufacture of zinc oxide. As to the remainder of the production, the statistics do not permit the division between blende and calamine, but it may be said with assurance that the major part is blende.

The production of zinc ore in 1909 was the largest on record. Another noteworthy feature of the statistics for 1909 is that each State made an increased production, which was due partly to the high price for zinc ore and partly to the development of new districts, which would probably have added to their production without the special stimulus that they

VIII. USES OF SPELTER IN THE UNITED STATES.
(In tons of 2000 lb.)

Purpose.	1905	1906 (*a*)	1907 (*b*)	1908 (*b*)	1909 (*b*)	1905	1906	1907	1908	1909
						Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Galvanizing	100,000	124,000	150,000	119,000	164,000	50	55	62.7	62.2	62.7
Brass-making	52,000	57,000	44,000	33,000	48,000	26	25¼	18.4	17.2	18.3
Sheet zinc	34,000	36,000	30,000	27,000	33,000	17	16	12.4	14.1	12.6
Lead desilverization	2,400	2,500	2,600	2,500	2,600	1¼	1	1.1	1.3	1.0
Other purposes (*a*)	10,854	6,000	12,894	10,000	14,000	5¾	2¾	5.4	5.2	5.4
Total	199,254	225,500	239,494	191,500	261,600	100	100	100	100	100.0

(*a*) The apparent falling off in the consumption of zinc for "other purposes" in 1906 is explained by a more complete itemization of the consumption in 1906: in other words, there was probably more spelter used for brass-making in 1905 than the above table shows. (*b*) The statistics of consumption for 1907 have been revised from those stated in *The Mineral Industry*, Vol. XVI, so as to include the consumption of reclaimed spelter, which is also included in the statistics for 1908 and 1909. For a full discussion of this subject see *Eng. and Min. Journ.*, June 12, 1909.

IX. PRODUCTION OF ZINC OXIDE IN THE UNITED STATES. (*a*)

Year.	Quantity.		Value.		Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Ton.		Short Tons.	Metric Tons.	Totals.	Per Short Ton.
1897	26,262	23,285	$1,686,020	$64.26	1903	59,562	54,034	$5,005,394	$83.69
1898	32,747	29,708	2,226,796	68.00	1904	59,613	54,081	4,523,414	75.88
1899	39,663	35,982	3,331,692	84.00	1905	72,603	65,859	5,808,240	80.00
1900	47,151	42,775	3,772,080	80.00	1906	77,800	70,573	6,257,361	80.43
1901	46,500	42,266	3,720,000	80.00	1907	85,390	77,449	7,731,100	73.28
1902	52 730	46,929	4,023,299	76.30	1908	65,100	59,046	5,876,342	90.26

(*a*) The figures for 1905 and 1906 include zinc-lead pigment, which was not included in the statistics for previous years.

received. This was the case with Butte, Miami (Okla.), Good Springs (Nev.), and probably Arizona. The larger production of New Mexico was due chiefly to the resumption of shipments from Magdalena.

A steadily increasing production is to be expected from Montana, Oklahoma and Wisconsin. Colorado will probably hold its own for a few years, after which it is likely to fall off, inasmuch as Leadville is understood to have no great reserves remaining, except in the Colonel Sellers mine. The future of Utah, New Mexico, Arizona and Nevada is uncertain, but probably they will maintain the tonnage of 1909 if spelter averages about 5.50c., St. Louis.

A remarkable development of 1909 was the large importation of ore from British Columbia and Mexico in spite of the tariff that went into effect shortly after the middle of the year. A great deal of ore was imported in anticipation thereof, but when the price for spelter rose so high in the fall, it became possible to bring in foreign ore and pay the duty.

X. PRODUCTION OF ZINC ORE IN THE UNITED STATES.
(In tons of 2000 lb.)

State.	1904	1905	1906	1907	1908	1909
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Arizona	....	....	....	....	....	7,908
Arkansas	(e) 1,900	2,200	4,200	4,088	2,582	(g) 320
Colorado	(a) 94,000	105,500	114,000	142,510	85,052	90,288
Idaho	*Nil.*	1,700	2,150	11,847	1,558	2,784
Kentucky	(d) 958	(d) 414	975	1,005	341	(g) 94
Miss.-Kan.	(b)273,238	(b)258,500	(b)280,260	297,126	273,420	304,581
Montana	*Nil.*	2,000	4,900	1,218	2,783	12,037
Nevada	*Nil.*	*Nil.*	7,080	4,593	1,445	4,609
New Mexico	(e) 21,000	17,800	30,000	4,281	2,290	19,163
New Jersey	(d)280,029	(d)361,829	404,690	368,710	399,232	479,699
Oklahoma	....	....	....	3,240	9,200	17,089
Tennessee	....	....	....	....	....	1,710
Utah	*Nil.*	9,265	10,700	9,043	709	18,130
Wisconsin	(c) 19,300	32,690	42,130	53,011	58,135	69,000
Others	(a) 2,600	(f) 3,800	(h) 850	(h) 2,241	(h) 1,520	572
Totals	693,025	795,698	905,175	902,923	838,377	1,027,984

(*a*) Estimated. (*b*) Production of Joplin district, plus output of southeastern Missouri, the latter as reported by the State mine inspector. (*c*) According to H. F. Bain, "Contributions to Economic Geology," 1904. (*d*) Report of State Geologist; crude ore. (*e*) Partly estimated. (*f*) Arizona, Nevada, Illinois, Iowa, Tennessee and Virginia. (*g*) These figures may be a little too low, there being a possibility that some ore originating in these States has been credited to other States, especially Missouri and Kansas. (*h*) Tennessee, Arizona and California.

XI. IMPORTS OF ZINC ORE INTO THE UNITED STATES.
(In tons of 2000 lb.)

Source.	1904	1905	1906	1907	1908	1909
British Columbia	2,100	8,561	600	1,157	6,157	9,163
Mexico	?	(a)32,164	(a)88,900	(a)108,800	66,383	90,707
Totals	?	40,725	89,500	109,957	72,540	99,870

(*a*) The actual tonnage of ore imported was somewhat greater than this figure, but it included some mixed ore, which for statistical purposes has been reduced to the zinc ore equivalent. This table is based on reports from the smelters of the ore received by them from these countries.

Zinc Mining in the United States.

Arizona.—This Territory became an important producer of zinc ore in 1910, the product (blende) coming chiefly from the Golconda mine, in the Union Basin district, Mohave county. The ore is of fairly high-grade, running up to 46 per cent. zinc, and containing a rather noteworthy quantity of gold.

Idaho.—The zinc ore production of Idaho in 1909 was derived from the Coeur d'Alene and Wood River districts, chiefly from the Success mine in the former district. This property is reported to have considerable reserves of ore.

Missouri and Kansas.—The receipts of zinc ore from Missouri and Kansas, as reported by the smelters, amounted to 304,581 tons in 1909. This total comprises the output of the Joplin district proper, but excludes that of Oklahoma. Out of the total shipments from Missouri and Kansas, 285,680 tons were received by 11 smelters. Ten of these smelters bought in excess of 10,000 tons each; six in excess of 25,000 tons. Five smelters, who make sulphuric acid as a byproduct, bought an aggregate of 122,410 tons. Certain others among these smelters make a specialty of producing a grade of spelter somewhat superior to what goes nowadays as ordinary prime western, and for that purpose buy selected ores. It is impossible to state the amount of such purchases, but we are safe in saying that the purchases of ore from which sulphuric acid is to be recovered, or special brands of spelter are to be made, in 1909 accounted for fully 50 per cent. of the total output of Missouri and Kansas.

In the remainder of the output is included the production of calamine and of blende that is below standard grade and sells ordinarily at a considerable discount. The Joplin blende is not, nowadays, by any means so uniform in quality as it used to be. A good deal more "sludge" is produced now than formerly, and also a good deal of "sheet ground" containing pyrites is worked, producing a concentrate that is higher in iron than the pristine ore of the district.

The competition for ore in the Joplin district has driven a number of smelters out of that market, there being several who did not purchase a pound of ore at Joplin in 1909. They have been unable to stay in that market in competition with those smelters who can bid relatively high for ore because they are going to make acid from it, or realize some other special advantage. This condition, which has been manifest for a long time in the narrowing margin between ore and spelter, signifies that in reality the producers of the ore realize its sulphur value.

I can indicate only approximately what the sulphur value of such ore is. Pyrites fines, containing about 45 per cent. sulphur, are worth in the Eastern market about 10c. per unit of 20 lb. Joplin blende of the best grade contains about 30 per cent. sulphur, the value of which is relatively less than in pyrites, partly because of the lower grade of the ore and partly because blende is less easily burned than pyrites. If a price were made per unit of sulphur in blende, it might be expected to be in the neighborhood of 7½c., corresponding to about $2.25 per ton of ore of the best grade. Consequently, if the smelters who formerly were able to purchase ore on a $14 margin are now able to do so only upon a $12 margin, they are in effect paying for about all the sulphur value of the ore, the market being established by those smelters who produce acid. This condition will, of course, tend to increase the number of smelters making that byproduct.

(By Jesse A. Zook.)—The steadily advancing prices inspired a campaign of prospecting that increased in interest toward the end of the year. The chief results from development work were experienced in the "sheet ore" area. The renewal of operations at Saginaw and Jackson, together with the large increase in the output of Spurgeon, contributed to the interest of the district. Shipments from Murray county, Oklahoma, came from the vicinity of Davis. Murray is the southern county of the old Chickasaw nation, separated from Texas by Red river, and almost centrally situated from east to west of the State. This ore was a zinc silicate of fair grade.

XII. MARGIN ON JOPLIN ORE IN 1909.

Month.	Spelter.	Ore.	Margin (*a*)	Month.	Spelter.	Ore.	Margin.(*a*)
January	\$50.91	\$38.48	\$12.43	July	\$53.57	\$41.28	\$12.29
February	48.34	34.46	13.88	August	56.91	44.56	12.35
March	46.99	34.77	12.22	September	57.59	44.78	12.81
April	49.11	35.99	13.12	October	61.54	46.04	15.50
May	50.73	37.82	12.98	November	63.56	48.29	15.27
June	53.57	40.00	13.57	December	62.21	47.97	14.24

(*a*) Margin = difference between value of 1020 lb. of spelter at St. Louis and 2000 lb. of 60-per cent. ore at Joplin.

XIII. AVERAGE MONTHLY PRICE OF ZINC BLENDE ORE AT JOPLIN, MO. (*a*)
(Dollars per 2000 lb.)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec	Year.
1900	30.23	29.36	28.45	28.42	26.92	25.00	24.23	25.67	24.25	24.25	24.45	25.40	26.50
1901	23.72	23.96	23.70	24.58	24.38	24.22	24.68	23.88	21.63	21.63	26.15	28.24	24.21
1902	26.75	27.00	28.00	28.85	29.23	34.10	34.37	32.50	33.58	33.58	32.10	29.25	30.73
1903	31.50	32.50	35.75	37.75	36.60	36.50	36.00	36.00	34.40	34.40	30.75	30.00	34.44
1904	32.12	34.00	36.00	36.40	34.63	32.62	35.00	37.00	40.40	40.00	44.25	46.13	37.40
1905	51.94	53.65	47.40	43.93	43.74	40.75	43.00	50.24	46.80	49.37	50.37	47.67	47.40
1906	49.33	49.25	45.60	44.00	41.50	44.20	43.88	44.38	43.20	42.50	44.43	45.55	44.82
1907	46.90	48.30	49.75	49.25	46.90	47.00	46.80	44.56	41.00	41.75	38.60	31.50	44.36
1908	37.60	36.63	36.19	35.40	34.19	34.06	34.55	36.53	37.63	35.95	39.13	42.75	36.63
1909	38.48	34.46	34.77	35.99	37.82	40.00	41.28	44.56	44.78	46.04	48.29	47.97	41.14

(*a*) Base prices for 60-per cent. zinc ore.

XIV. SHIPMENTS OF ORE FROM THE JOPLIN DISTRICT.
(In tons of 2000 lb.)

Year.	Zinc Ore.	Lead Ore.	Year.	Zinc Ore.	Lead Ore.
1896	155,333	27,721	1903	234,773	28,656
1897	177,976	30,105	1904	267,240	34,362
1898	234,455	26,687	1905	252,435	31,679
1899	255,088	23,888	1906	278,930	39,189
1900	248,446	29,132	1907	286,538	42,065
1901	258,306	35,177	1908	258,628	38,532
1902	262,545	31,625	1909	295,371	43,659

XV. PRODUCTION OF THE JOPLIN DISTRICT.
(In tons of 2000 lb.)

	Zinc Ore.				Lead Ore.			
	1909.	1908.	Inc.	Dec.	1909.	1908.	Inc.	Dec.
Webb City—Carterville.	98,696	78,134	20.562	....	20,768	18,019	2,749	....
Joplin	49,454	56,263	....	6,809	6,743	7,201	....	458
Duenweg	16,707	12,890	3,817	....	2,493	1,940	553	....
Alba-Neck	11,473	8,593	2,880	....	3,124	2,422	702	....
Prosperity	11,245	12,888	....	1,643	161	94	67	....
Oronogo	7,934	9,034	....	1,100	967	410	557	....
Carthage	6,969	4,289	2,680	....	8	11	....	3
Sarcoxie	4,428	2,455	1,973	....	....	....	....	....
Zincite	3,698	2,298	1,400	....	92	85	7	....
Cave Springs	1,923	1,028	895	....	10	6	4	....
Carl Junction	1,608	1,531	77	....	34	71	....	37
Jasper County	214,135	189,403	24,732	....	34,400	30,259	4,141	....
Granby	13,947	11,800	2,147	....	333	910	....	577
Spurgeon	8,536	7,783	753	....	1,956	1,686	270	....
Jackson	1,562	....	1,562	....	184	....	184	....
Saginaw	1,368	....	1,368	....	130	....	130	....
Wentworth	345	655	....	310	....	....	....	....
Seneca	23	18	5	....	49	197	....	148
Newton County	25,781	20,256	5,525	....	2,652	2,793	....	141
Aurora	12,086	9,293	2,793	....	342	223	119	....
Stott City	630	159	471	....	12	....	12	....
Lawrence County	12,716	9,452	3,264	....	354	223	131	....
Dade County	61	....	61	....	....	....	....	....
Barry County	18	....	18	....	....	....	....	....
Greene County	....	1,527	....	1,527	41	59	....	18
KANSAS.								
Galena	17,319	18,249	....	930	1,871	2,909	....	1,038
Badger	8,244	10,100	....	1,856	152	509	....	357
Playter	....	249	....	249	....	37	....	37
Cherokee County	25,563	28,593	....	3,035	2,023	3,455	....	1,432
OKLAHOMA.								
Miami	11,585	6,652	4,933	....	3,853	1,378	2,475	....
Quapaw	5,117	3,389	1,728	....	320	363	....	43
Peoria	371	332	39	....	....	1	....	1
Ottawa County	17,073	10,373	6,700	....	4,173	1,742	2,431	....
Murray County	16	....	16	....	....	....	....	....
Missouri	252,711	220,638	32,073	....	37,447	33,334	4,113	....
Kansas	25,563	28,598	....	3,035	2,023	3,455	....	1,432
Oklahoma	17,089	10,373	6,716	....	4,173	1,742	2,431	....
Joplin District	295,363	259,609	35,754	....	43,643	38,531	5,112	....

Montana.—This State became a large producer of zinc ore in 1909, and is undoubtedly destined to attain an important position in the industry. The production is made by the Elm Orlu, and the Butte & Superior mines at Butte, the two properties adjoining. According to A. H. Wethey, the crude ore averages about 21 per cent. zinc, 3 per cent. iron, 2 per cent. copper, 10 per cent. silica, 25 oz. silver and $1 gold per ton, while the concentrates average 46 per cent. zinc, 5 per cent. iron, 2 per cent. copper, 10 per cent. silica, 25 oz. silver and $1 gold per ton.

The ore reserves of these mines are large. About three tons of crude ore are reduced to one ton of concentrates, and the cost of the latter, delivered at smelting works in Kansas and Oklahoma should not be more than $22 per ton. The Butte & Superior has suffered from managerial difficulties, but these will doubtless soon be corrected, after which the company may be expected to make a large production of zinc ore.

New Jersey.—The production of the New Jersey Zinc Company, at Franklin Furnace, in 1909, was 428,303 long tons, of which 72,858 were taken from the open cut. This was an increase of 71,846 tons over 1908. The Palmer shaft, commenced in 1906, was continued to the 1150-ft. level, or 1445 ft. on the incline.

New Mexico.—The zinc ore production of this Territory in 1909 was made chiefly by the Graphic and Kelly mines at Magdalena. Experiments with the process of pneumatic concentration were made in this district. The United States Smelting, Refining and Mining Company purchased the Cleveland group of mines near Silver City and commenced development by churn drilling. Small quantities of ore were shipped from Hachita, Cook's Peak, Hanover, and Los Cerrillos.

Oklahoma.—According to an article in *Eng. and Min. Journ.* of January 8, 1910, the mines of the Miami district are at Hattonville, 2½ miles north of Miami. The ground that has been prospected and partially developed covers an area ½ mile wide and about two miles long. The development work so far accomplished shows that the ore deposit extends along a line approximately north 20 deg. west. According to the local operators, the ore occurs in a series of parallel "runs" 50 to 80 ft. wide which pitch slightly toward the north. The present workings range from 100 to 175 ft. in depth, while farther north a number of drill holes are reported to have encountered ore at a greater depth. The surface of the country is a flat open prairie with no rock outcrop near the mines. The ore was accidentally discovered while drilling a well for domestic purposes.

A geological section from the surface down consists of approximately 25 ft. of soil and clay, 50 to 60 ft. of shale and soapstone, 8 to 10 ft. of oil-bearing limestone, which is usually the cap rock. Beneath this is a stratum 6 to 20 ft. thick containing both lead and zinc in a cherty oil-bearing limestone. The bedrock beneath this consists of a thin stratum of chert. At present all the mining is carried on in the ore-bearing formation above the chert bedrock, and in many instances the ore is found to extend up to and slightly into the soapstone roof. With this roof it is necessary to drive narrow drifts and use more or less timber, leaving large pillars, thus adding to the expense of mining. In a few instances ore has been found below the chert bed.

The district is well equipped with mills, there being 18 or 20 complete and ready for operation. The operating mills are the Emma Gordon, Queen City-Joplin, Old Chief, Okmulgee, Chatham Oil and Gas, Turkey Fat, King Jack and New State. In addition to this there are two tailings plants in operation and a third one now under construction. The above mills have a capacity of 50 to 200 tons each, while the Emma Gordon is a 400-ton mill. These are all rated on Joplin ore. However, the character of the ore is such that most of the mills are operated on about half the rated capacity, and even then the losses are high. Among some of the dozen idle mills are a number of new ones that have only recently been completed, while others have been run a short time, and for one reason or another have not been found profitable. In many cases the mills are built before the ground is thoroughly proven and developed, and by the time the mill is ready for operation, operating funds are depleted and work must cease or wait until the mill and land can be leased to someone else.

The high royalty in this district works a severe hardship on the operators, and if it were not for the fact that the ore is exceedingly rich it would be almost impossible for any mill to pay dividends. The owner of the land receives 5 per cent. royalty. This is paid by a royalty company, which sub-leases the property to the prospector for 15 to 20 per cent. The prospector does a little work on the land and in turn leases it to a milling company for 25 to 30 per cent. In one or two cases the company putting up the mill has sub-leased the entire plant for 35 per cent., with the understanding that the operator keeps up the mill and leaves it in good condition at the expiration of the lease. In some cases a bonus of \$2000 or \$3000 with a royalty of 27½ per cent. is paid by the operator who has to make an additional outlay of \$5000 to \$15,000 for a mill, depending upon the scale he proposes to work.

A number of the tailings dumps have been leased at 30 to 50 per cent. of the gross output. At this price the lessee builds his own mill. The high royalty on the tailings is largely the fault of the man who proposes to work them. The dirt being rich, it looks as if money would be easily made in working it over, and in his enthusiasm the operator in some cases has actually offered to pay this high rate, asking no questions.

An attempt is being made to reduce the royalties. Some prospectors refuse to lease from the royalty company, and are endeavoring to obtain their leases direct from the fee owner. By doing this, at least one royalty of 10 to 15 per cent. can be cut out entirely. Some of the old leases that have been forfeited from one cause or another are now being sub-let on a closer margin.

The State taxes imposed on mining companies in Oklahoma are also high. One-half of one per cent. is charged on the gross output of the mines; this has to be paid even though the mine be running at a loss. In addition to this there is a tax on the net profits, as well as the regular tax on the assessed valuation of the property.

The same type of mill that is used in the Joplin district has been installed at Miami. In fact a large number of the mills that have been built are ones that have been moved direct from the Joplin field. While this type of mill may be the best one available at the present time for treating of these ores, there is a good field for some other type of mill. The character of the ore is such that these mills do not recover to exceed 50 per cent. of the metallic content. The tailings losses are exceedingly high. This is due largely to the fact that the ore carries a notable percentage of petroleum and bitumen. The hydrocarbons make the ore more or less sticky and there is a tendency to clog the jig beds. A portion of the oil floats off and carries fine blende with it. A large percentage of the ore is finely disseminated, and to recover it will require fine crushing.

The present practice is to crush the ore to $\frac{1}{4}$-inch size, run it over a roughing jig; the spigot product goes to a finishing jig. The tailings from the roughing jig are disposed of as waste, while those from the finishing jig are recrushed and passed over a sand jig. The majority of the mills have one or two Wilfley or other make of tables, upon which the slimes are treated. In some cases no tables are used.

The ore as it comes from the mine contains three parts blende to one of galena, with a high percentage of marcasite. It is hard to obtain a finished product that contains over 50 to 52 per cent. zinc. The iron content of the concentrate is high.

Utah.—The zinc ore production of this State in 1910 was furnished chiefly by the Daly Judge mill at Park City, and the Huff electrostatic mill of the United States Smelting Company, at Midvale, the latter treating Bingham ore. Small quantities of zinc ore were produced by several other districts in this State.

Virginia.—None of the zinc mines of this State was in regular operation throughout 1909. Some ore was gleaned from the old Bertha workings and milled at Austinville. The oxide furnaces of the Bertha Mineral Company, at Austinville, were run on Bertha tailings. Experimental work was carried on at the hard-rock mill, pending the results of which the mines are idle. The problem at Austinville is to concentrate the disseminated zinc-lead sulphide ore with reasonable recovery. The smelting works at Pulaski were run more or less continuously, chiefly on oxide from Austinville and galvanizers' dross. Some prospecting was done by the Virginia Mining and Milling Company, on the Osborn property on Copper creek, about 10 miles south of Castlewood in Russell county.

Wisconsin. (By J. E. Kennedy.)—The production of zinc ore in the Wisconsin district in 1909 was about 75,000 tons, being the largest on record. The increase in production was actually greater than is indicated by the statistics, inasmuch as the average grade of the ore produced in 1909 was higher than in 1908. During the first four months of 1909 the weekly production of crude concentrate was 1000 to 1200 tons. The rate steadily increased, and toward the close of the year exceeded 2000 tons per week. The shipments amounted to 68,221 tons. The stock in bins at the end of the year was 6000 tons.

The year opened with a base price of $40 per ton for 60-per cent. ore, the market advancing to $43 during January. In February there was a decline to $37@38, at which point the market remained until the middle of April. Then there was some fluctuation with a general rising tendency, $50 being reached toward the last of August. After a decline to $48 there was a further rise, $51 being paid during November and December.

Eleven roasters were in almost continuous operation during 1909, including three of the Mineral Point Zinc Company and two of the Joplin Separating Works. The electrostatic separating plant at Platteville continued in operation.

Since November 6 the report of zinc ore shipments from this district has been based on the quantity sent to smelting works, either from the mines directly or from the three separating plants. Formerly, all of the zinc ore shipped to the Mineral Point Zinc Company's separating plant at Mineral Point was classified as "Ore to Smelting Works." About 5000 tons of calamine were included in the year's output.

Among the mining districts, Platteville, Benton, Hazel Green, Mifflin, Highland, Cuba City, Linden, Rewey, Galena, Livingston, Shullsburg, Mineral Point, Montfort, Dodgeville and Potosi stood in importance in the order named. One hundred mining companies contributed to the production, 75 of which were equipped with modern milling plants. Eight new concentrating mills were constructed and 11 second-hand mills were moved to new properties. Rich deposits of zinc ore were opened at new diggings, an old lead camp lying between Benton and Shullsburg, which is new territory for zinc mining. A central power plant at Galena, which will furnish power to mines between Platteville and Galena, was under construction.

Zinc Mining in Foreign Countries.

Australia.—The Sulphide Corporation, of New South Wales, reported a profit for the year ended June 30, 1909, of £153,382. The new mill has justified expectations and the tonnages, costs and recoveries in this plant have shown important improvements. The tonnage of crude ore treated was 195,332, from which a production of 42,354 tons of lead concentrates carrying 32.3 oz. silver and 60.1 per cent. lead, and 67,981 tons of zinc concentrates carrying 16.6 oz. silver, 11.4 per cent. lead and 42.5 per cent. zinc were obtained.

The costs were £4 16s. 8d. per ton of lead concentrates, and 18s. 6d. per ton of zinc concentrates; the recoveries being 74.7 per cent. of lead in the galena concentrates and 85.5 per cent. of the zinc in the blende concentrates. The distilling of zinc concentrates at the Cockle Creek works has been suspended owing to results (in consequence of the reduced value of the lead and silver in residues) being less favorable than those obtainable by selling in the open market.

The new mill treated 195,332 tons. In the lead section the product was 42,354 tons of lead concentrates assaying 60.1 per cent. lead and 9.9 per cent. zinc, and 152,978 tons of byproducts. The zinc section treated 157,907 tons, producing 67,981 tons of zinc concentrates carrying 42.5 per cent. zinc and 11.4 per cent. lead, and 89,926 tons residues. The recovery of both sections combined was 94.8 per cent. silver, 97.5 per cent. lead and 89.5 per cent. zinc.

XXI. PRODUCTION OF ZINC IN NEW SOUTH WALES.
(In tons of 2240 lb.)

	1903	1904	1905	1906	1907	1908	1909
Spelter	286	299	544	1,008	984	1,035	*Nil.*
Zinc in ore exported	14,625	22,318	30,637	33,427	76,645	113,853	144,018

The Zinc Corporation, working on Broken Hill tailings, treated 227,502 tons during 1909, which yielded 84,698 tons of zinc concentrates, containing 46.02 per cent. zinc, 15.08 oz. silver per ton, and 7.3 per cent. lead; and 6411 tons of lead concentrates, containing 56.98 per cent. lead and 38.49 oz. silver per ton. The extractions obtained during 1909 in the two products combined were 86.3 per cent. of the zinc, 74.7 per cent. of the lead and 75.9 per cent. of the silver, which is an improvement over the previous year.

Working costs ranged from 9s. ($2.19) to 9s. 6d. ($2.31) per ton of tailings. On account of an insufficient number of Wilfley tables in the retreatment plant, the grade of the zinc concentrates fell off from over

47 per cent. zinc to about 45 per cent. zinc. At the close of 1909, the installation of additional tables again raised the grade to over 47 per cent., with a corresponding increase in the production of lead concentrates. A further improvement is anticipated.

(By F. S. Mance.)—The operations in the Broken Hill field in 1909 showed clearly that the difficulties hitherto experienced in recovering the zinc from the vast heaps of accumulated tailings were successfully surmounted. The Elmore plant installed by the Zinc Corporation proved an unqualified success. The British Broken Hill Company is remodeling its mill and intends adding an Elmore plant, while Block 10 Company also proposes to install a similar plant. At the Central mine, operated by the Sulphide Corporation, the flotation processes are doing good work, and have entirely superseded the magnetic plants. The Amalgamated Zinc (De Bavay's, Ltd.) is erecting a new mill consisting of two units. It is expected to have one unit in operation by January, 1910, and the other some three months later. When in full swing it is estimated that the output will reach 100,000 tons of concentrates per annum. Contracts have been entered into for the sale of 90,000 tons of concentrates per annum for the next three years, and 70,000 tons per annum for the succeeding seven years. The Broken Hill Proprietary Company reports that the tube mills installed in connection with the zinc-treatment plant showed a great improvement in the recovery of the zinc. The flotation plant of this company also produced a large quantity of zinc concentrates. The construction of the spelter plant at Port Pirie was pushed, and it should be completed and in operation at an early date. Even after making considerable allowance for the fact that expectations as to the results likely to be secured may not be fully realized it is apparent that the Broken Hill field has become an important factor in the world's supply of spelter.

Canada.—The zinc ore production of Canada in 1909 came chiefly from British Columbia, where there was more activity than for several years previously. The Olden mine in the county of Frontenac, Ontario, produced 895 tons of ore.

China.—A good deal of zinc ore has been coming from China during the last two or three years, but there is considerable uncertainty as to its origin and conditions of production. According to one report, there exists in the Province of Quang-Yen a deposit of zinc blende of exceptional richness and purity. According to the London *Mining Journal* of Dec. 18, 1909, the Trang Da mine in Tonkin exported 6000 metric tons of zinc ore in 1908, while the Lang Hit and Lang Mac mines together exported 3000 tons. This ore was chiefly calamine.

(By T. T. Read.)—Practically all the production of zinc ore in China comes from the Hêng-choou and Yang-cheu perfectures of Hunan province. In former years there has been a considerable export of these ores to Belgium, but in 1909 the export was almost nothing and the output was said to have been a very poor one. There is a small yearly export of spelter from Tientsin, the source of which is exceedingly difficult to determine, but it is probably spelter from Hunan that has been brought to Tientsin for use in making brass coins in the provincial mints, the surplus spelter being exported. The native production of zinc must be an appreciable quality, as the amount of brassware and coins annually produced testifies, but there is no way of ascertaining the amount.

Germany.—According to the *Statistik der oberschlesischen Berg- und Hüttenwerke* for 1909, the average number of men employed in the zinc mines in Silesia in 1909 was 13,159, against 13,010 in 1908. The production was: Calamine, 195,235 tons; blende, 402,582 tons; lead ore, 58,568 tons; and pyrites, 7817 tons. In the roasting works the average number of men was 2701. The quantity of blende roasted was 395,387 tons, yielding 323,123 tons of roasted blende; the production also included 152,606 tons of sulphuric acid and 1671 tons of anhydrous

XIX. GERMAN IMPORTS AND EXPORTS.
(In centners of 100 kg.)

	Imports.				Exports.			
	1906.	1907.	1908.	1909.	1906.	1907.	1908.	1909.
Spelter	370,359	284,591	326,223	445,138	633,947	622,379	689,254	763,104
Zinc Sheets	808	1,171	2,855	993	172,979	214,759	186,609	189,614
Broken Zinc	22,777	10,264	18,999	24,760	57,007	66,686	63,648	60,543
Zinc Ore	1,790,360	1,847,026	1,998,403	2,011,100	426,055	348,632	394,502	520,258
Oxide of Zinc	52,310	70,492	50,483	45,198	141,057	187,633	177,367	184,065
Lithopone	15,104	22,080	20,319	24,822	79,947	94,951	86,354	75,631

liquid sulphurous acid. In the production of spelter 8105 men were engaged, receiving 7,804,393 marks in wages, which compares with 8444 men and 8,231,056 marks in 1908. The output amounted to: Spelter 139,255 tons (against 141,465 in 1908), zinc dust 5490 tons, lead 1231 tons, cadmium 37,187 kg. The zinc rolling works employed 974 working men, who received 971,652 marks in wages, as against 976 men and 924,783 marks in 1908. The production of zinc sheets amounted to 47,214 tons, valued at 21,095,526 marks, as against 47,206 tons, valued at 19,273,824 marks, in 1908.

(By Paul Speier.)—Owing to decreased activity in the building trade and a reduction in the consumption by related industries, transactions in zinc sheets were not very satisfactory in some months of 1909. In the wholesale trade from 50 to 56 marks per 100 kg. was held as standard price at the beginning of the year, but quotations advanced in proportion to the increasing spelter prices, and toward the end of the year from 56 to 61 marks per 100 kg. was paid, according to the quantities purchased and the time of delivery. At the beginning of September the Rhenish-Westphalian works joined the Association of Silesian Zinc Rolling Works. The name of this association, which now embraces the whole of the 13 German works—viz.: Silesia, Ohlau, Jedlitze, Tiela, Hohenlohehütte, Schoppinitz, Antonienhütte, Kunigunde, Grillo in Oberhausen and Hamborn, Stolberg Gesellschaft, Humboldt-Kalk and Grove & Welter—has been changed into "Association of German Zinc Rolling Works," with its head office in Berlin. The principal competitor of the association in the export trade is the Vieille Montagne company, and negotiations have been opened by the German association to induce the Belgian company to enter into a price agreement.

In view of the low quotations ruling in London, considerable quantities of zinc white were sold at low prices by wholesale merchants at the end of 1908 for delivery during 1909. The average price of zinc white, when compared with white lead and lithopone, was low enough to exercise a favorable influence upon consumers. After having been in existence for a period of eight years, the convention of lithopone manufacturers expired at the end of 1909. The efforts to create a new convention, which, in face of the very considerable overproduction, appears to be necessary, have so far remained without success. Prices have receded in such a manner that the manufacturers who produce on a large scale are working with hardly any profit, while the smaller producers have to work at a loss. To make matters even worse, there are now some new lithopone works in course of erection, and in these circumstances it is scarcely probable that the formation of a new convention will be possible for some considerable time to come.

The business in zinc dust in 1909 was by no means satisfactory, and at times it had even to be carried on at a loss. In spite of the increase in spelter quotations the price of zinc dust could not be proportionately improved. It was only during the second half of the year that a somewhat better demand commenced, and some large quantities were shipped to America shortly before the introduction of the new tariff. The price at the end of 1909 was 43.75 marks per 100 kg., inclusive of barrels, f.o.b. Stettin.

Mexico.—Zinc mining in this country received a decided set-back upon the imposition of the new American tariff, but later on, upon the advance in spelter, it became possible to resume shipments to the United States in spite of the tariff. However, so long as the Payne-

Aldrich tariff prevails the chief market for Mexican zinc ore must be looked for in Europe, except when the American price for spelter is materially above European parity.

According to a recent U. S. consular report the freight tariff of the National railway lines of Mexico, which went into effect Dec. 23, 1909, has made it slightly more profitable to ship zinc ore from Chihuahua to European points by way of Tampico than to send it to the Kansas smelters by El Paso, Tex. The rate on zinc ore from Chihuahua to El Paso was raised from $1.89 to $2.97 per ton, while the rate from Chihuahua to Tampico was lowered from $4.87 to $4.60 per ton. The increase of $1.08 in freight on shipments to the United States, when augmented by the duty into the United States of 1c. per lb. on the zinc contents of ore containing 25 per cent. or more of zinc, gives European markets a small advantage in buying in this district. The maximum freight to ports in England or Germany is $7.60 per ton—$4.60, Chihuahua to Tampico, and $3, Tampico to England or Germany. The ocean charge is sometimes as low as $2 per ton, when the ore is taken as ballast or in default of a return cargo. To deliver Chihuahua ore to the Kansas smelters costs $7.20 per ton—$2.97, Chihuahua to El Paso, Tex., and $4.23, El Paso to the smeltery. The brokerage charges at the United States border are higher than the same charges on zinc ore sent to England or Germany, owing to the contents of this ore being dutiable in the United States.

Norway.—A wet zinc concentration plant near Gru, in Hadeland, was started in November, 1909, and at the end of the year had treated 12,700 metric tons of ore. The Bergwerks A. G. Norge reported for 1909 an output of 5400 tons. Several important discoveries of zinc ore in the eastern part of Norway were reported during 1909.

Russia.—In addition to the production of Poland, this empire is now exporting ore from mines north of Olga bay in the Far East. These mines are only about 30 versts from the coast, with which they are connected by railway. The ore is shipped to Hamburg.

The Spelter Markets in 1909.

New York.—At the opening of 1909 the market ruled above 5c. St. Louis. Under the influence of the unfavorable conditions developing at that time in the iron and steel industry, prices began to weaken and declined continuously until 4.60c. St. Louis was reached late in February. This low figure attracted buying by both consumers and speculators, and in consequence a steadier tone prevailed during March. Moreover, the smelters were reluctant to enter orders, due to the fact that ore prices had not yielded in proportion to the decline in the refined metal. The strength of the ore market was in a measure due to the sentimental influence created by the efforts of the Joplin miners to shut out Mexican and British Columbia ore, by causing a prohibitive duty to be placed on zinc ore in the Payne tariff bill. This factor made itself felt more strongly as time passed, and combined with the revival in business in general, and in the iron and steel industry in particular, caused prices to harden, and under large transactions the market moved upward by leaps and bounds in April, May and June until 5.30c. St. Louis was realized toward the end of the last-named month. At about this time it became known that the leading buyers had purchased large lots of foreign spelter, ostensibly for drawback purposes, the quantities being estimated at from 8000 to 10,000 tons. This news created at first considerable consternation, bringing about recessions early in July, but the influence wore off as the month advanced, being overshadowed by the developments in Washington, where it became clearer from day to

MONTHLY AVERAGE PRICES OF SPELTER AND SHEET ZINC.
(In cents per lb.)

Month.	1908. (a) Spelter.	1908. (b) Sheet Zinc.	1909. (a) Spelter.	1909. (b) Sheet Zinc.
January	4.518	6.44	5.141	6.44
February	4.788	6.44	4.889	6.44
March	4.665	6.44	4.757	6.21
April	4.645	6.44	4.965	6.21
May	4.608	6.44	5.124	6.21
June	4.543	6.44	5.402	6.325
July	4.485	6.44	5.402	6.44
August	4.702	6.44	5.729	6.808
September	4.769	6.44	5.796	6.90
October	4.801	6.44	6.199	7.187
November	5.059	6.44	6.381	7.36
December	5.137	6.44	6.249	7.36
Year	4.726	6.44	5.503	6.657

(a) At New York. (b) At Lasalle-Peru, Illinois.

day that the mining interests would win their fight for a duty on zinc ore, which had been fixed at 1c. per lb. of zinc contained on such grades as are available for the manufacture of spelter. This expectation was realized at the final passage of the bill early in August.

While the return of prosperity began to be reflected in an expanding consumption of spelter for all purposes, the output of the metal continued restricted, as necessarily considerable time must elapse until the quantities formerly supplied from Mexico could be replaced by an increased output in this country.

Everything had, therefore, shaped itself toward laying the foundation for a strong advance in the market, and the forward movement was resumed with great vigor during August. The influx of orders became so heavy that, in addition to the current consumption, the bulk of the stock which had been carried over from the previous year was gradually absorbed during September, October and November. In October, the price—for the first time since the panic of 1907—crossed 6c. in St. Louis, and the advance did not stop until 6¼c. St. Louis was reached toward the end of that month. The market remained active and firm around this level throughout November. The year closed with spelter at 6@6.05c. St. Louis, and 6.15@6.20c. New York.

XXII. AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN ST. LOUIS.

Year.	Jan.	Feb	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1903....	4.688	4.681	5.174	5.375	5.469	5.537	5.507	5.550	5.514	5.350	4.886	4.556	5.191
1904....	4.673	4.717	4.841	5.038	4.853	4.596	4.723	4.716	4.896	5.033	5.363	5.720	4.931
1905....	6.032	5.989	5.917	5.667	5.284	5.040	5.247	5.556	5.737	5.934	5.984	6.374	5.730
1906....	6.337	5.924	6.056	5.931	5.846	5.948	5.856	5.878	6.056	6.070	6.225	6.443	6.048
1907....	6.582	6.664	6.687	6.535	6.291	6.269	5.922	5.551	5.086	5.280	4.775	4.104	5.812
1908....	4.363	4.638	4.527	4.495	4.458	4.393	4.338	4.556	4.619	4.651	4.909	4.987	4.578
1909....	4.991	4.739	4.607	4.815	4.974	5.252	5.252	5.579	5.646	6.043	6.231	6.099	5.352

XXIII. AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1900....	4.65	4.64	4.60	4.73	4.53	4.29	4.28	4.17	4.11	4.15	4.29	4.25	4.39
1901....	4.13	4.01	3.91	3.98	4.04	3.99	3.95	3.99	4.08	4.23	4.29	4.31	4.07
1902....	4.27	4.15	4.28	4.37	4.47	4.96	5.27	5.44	5.49	5.38	5.18	4.78	4.84
1903....	4.87	5.04	5.35	5.55	5.63	5.70	5.66	5.73	5.69	5.51	5.39	4.73	5.40
1904....	4.863	4.916	5.057	5.219	5.031	4.760	4.873	4.866	5.046	5.181	5.513	5.872	5.100
1905....	6.190	6.139	6.067	5.817	5.434	5.190	5.396	5.706	5.887	6.087	6.145	6.522	5.882
1906....	6.487	6.075	6.209	6.078	5.997	6.096	6.006	6.027	6.216	6.222	6.375	6.593	6.198
1907....	6.732	6.814	6.837	6.685	6.441	6.419	6.072	5.701	5.236	5.430	4.925	4.254	5.962
1908....	4.518	4.788	4.665	4.645	4.608	4.543	4.485	4.702	4.769	4.801	5.059	5.137	4.726
1909....	5.141	4.889	4.757	4.965	5.124	5.402	5.402	5.729	5.796	6.199	6.381	6.249	5.503

London.—Prices opened at £21¼ for ordinary brands and closed at £21⅝@21¾. The galvanizing trade showed signs of expansion and sheet zinc was in some cases advanced in price. In February the price drifted down to £21, notwithstanding further improvement in the galvanizing trade. At this basis some speculative business developed, which was followed by the announcement of the formation of the long-projected syndicate, whereby the German, Belgian and Dutch producers, with one or two exceptions, had combined to control production and, to some extent, prices also. The announcement that the German selling agency was holding for prices above those ruling in London was the signal for brisk buying, both speculative and consumptive, which continued up to the end of the month and carried prices to £22¾. Early in March the convention reduced its price to £22¼ for London delivery. This was still higher than the price actually ruling, but the reduction indicated weakness and prompted holders of second-hand parcels to accept down to £21$\frac{1}{2}$, or less. By the middle of the month the price had fallen to £21$\frac{1}{4}$, but with a small rally closed at £21$\frac{3}{8}$.

April was characterized by a general depression and small business. Some attention was attracted to the American market where prices ruled at one time about £2 over London, and orders were reported taken in Europe for shipment to America. The closing price for the month was £21$\frac{5}{16}$. In May business became more active, and although the fluctuations were narrow their tendency was generally upward. Toward the middle of the month it became known that the leading German producer, who had theretofore remained outside of the Convention, had finally joined it. Another encouraging feature in the market was the purchase of an important quantity of the metal for shipment to America. The closing prices for the month were £22@22$\frac{1}{8}$. June was uneventful, the closing price being £22@22$\frac{1}{8}$.

July was also uneventful on the whole, but the market was strengthened by large sales made to America. Toward the middle of the month the Galvanized Iron Association was dissolved in consequence of keen competition by outside firms. The closing price was £22. This price prevailed in August up to the 27th, when the Convention made an advance. This, together with improved demand from the galvanizers, was reflected on the London market, where the price rose to £22$\frac{7}{16}$. In September the Convention made a further advance of 5s., and meeting with but little outside competition another advance was made, the closing price being £23$\frac{1}{8}$@23$\frac{1}{4}$.

XXIV. AVERAGE MONTHLY PRICE OF SPELTER IN LONDON.
(Pounds sterling per ton of 2240 lb. of good ordinary brands.)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£	£	£	£	£	£	£	£	£	£	£	£	£
1905	25.063	24.594	23.825	23.813	23.594	23.875	23.938	24.675	26.375	28.225	28.500	28.719	25.433
1906	28.225	25.844	24.563	25.781	27.000	27.728	26.800	26.938	27.563	28.075	27.787	27.938	27.020
1907	27.125	25.938	26.094	25.900	25.563	25.469	23.850	21.969	21.050	21.781	21.438	20.075	23.771
1908	20.563	20.875	21.075	21.344	19.906	19.000	19.031	19.350	19.563	19.750	20.875	20.625	20.163
1909	21.225	21.563	21.438	21.531	21.975	22.000	21.969	22.125	22.906	23.200	23.188	23.094	22.185

In October the market held steadily at £23$\frac{1}{8}$@23$\frac{1}{4}$, and about the same price prevailed during November. December was not characerized by anything of particular interest, and the year closed with the market at £23@23$\frac{1}{8}$,

Bibliography of Zinc in 1909.

Anonymous. "Electric Zinc Smelting." (*Electrochem. and Met. Ind.*, Nov., 1909; 4¼ pp.)

ANONYMOUS. "Electrostatic Separation at the United States Zinc Plant." (*Mines and Methods,* Nov., 1909; 4 pp.)

ANONYMOUS. "Un Ensayo Industrial de Electrometalurgia del Cinc." (*Revista Minera,* Aug. 24, 1909; 2½ pp.)

ANONYMOUS. "Zinc Corporation, Ltd." (*Eng. and Min. Journ.,* Jan. 23, 1909; 1 p.)

BURN-MURDOCH, J. H. "The Process of Sherardizing with Notes on Other Galvanizing Methods." (*Brass World,* Nov., 1909; 5 pp.)

CHAPMAN, TEMPLE. "Departure in Sheet-Ore Mining in the Joplin District." (*Eng. and Min. Journ.,* May 8, 1909; 1½ pp.)

COWPER, COLES, S. "Vapor-Galvanizing." (*Journ.* Soc. Chem. Ind., Apr. 30, 1909; 4¼ pp.)

ELMORE, STANLEY. "Elmore Vacuum Process at Broken Hill, New South Wales." (*Min. Journ.,* Feb. 20, 1909; 2½ pp.)

ERICSON, ERIC. "Determination of Lead and Cadmium in Spelter." (*Eng. and Min. Journ.,* May 22, 1909; 1 p.)

GAMBOA, L. LLOYD. "Minerales Cinciferos de Picos de Europe." (*Revista Minera,* June 1, 8 and 16, 1909; 7½ pp.)

HAEGE, T. "Der Elmore Vakuum Prozess auf den Werken der 'Zinc Corporation, Limited,' zu Broken Hill Neu-Sud-Wales." (*Oest. Zeit. f. B. u. H.,* July 31, 1909; 2½ pp.)

HANNA, P. C., VOETTER, T. W., and MARTIN, L. A. "Development of Zinc Mining Industry in Mexico." (*Min. World,* July 3, 1909; 2½ pp.)

HOOVER, H. C. "Elmore Processes Applied by Zinc Corporation." (*Eng. and Min. Journ.,* July 31, 1909; 2½ pp.)

HUGHES, HARRY H., and HALE, HARRISON. "Crude Petroleum as a Reducing Agent for Zinc Ores." (*Journ. Ind. and Eng. Chem.,* Dec., 1909; 1 p.)

KENNEDY, J. E. "Mining Laws and Lease System in Wisconsin Zinc District." (*Eng. and Min. Journ.,* Apr. 24, 1909; 1 p.)

KEYES, C. R. "Migrations of the Joplin Zinc Belt." (*Eng. and Min. Journ.,* May 22, 1909; 2 pp.)

KEYES, C. R. "Ozark Lead and Zinc Deposits: Their Genesis, Localization and Migration." (*Bull.,* A. I. M. E., Feb., 1909; 45 pp.)

LEPIARCZYK, V. "Beitrage zur Chemie des Zinkhutten-prozesses." (*Metallurgie,* July 8, 1909; 10½ pp.)

LESHER, C. E. "Electrothermic Reduction of Zinc." (*Bull.,* Colo. Sch. Mines, Jan., 1909; 28 pp.)

LINDGREN, WALDEMAR. "The Tres Hermanas Mining District." (*Bull.* 380-C, U. S. Geol. Surv., 1909; 10 pp.)

MCGREGOR, F. S. "Successful Zinc Separation by U. S. Smelting Company." (*Min. World,* Nov. 6, 1909; 1 p.)

OSGOOD, SAMUEL W. "The Commercial Aspect of Tennessee Zinc." (*Min. World,* July 17, 1909; 2 pp.)

PETERS, F. "Neuerungen in der Elektrometallurgie des Zinks und des Kadmiums." (*Glückauf,* Sept. 25, 1909; 12 pp.)

PIEGZA. "Die neue bleideaufbereitungsanlage des Zink- und Bleierzbergwerks 'Neue Helene' bei Scharley (Oberschlesien)." (*Glückauf,* June 5, 1909; 5½ pp.)

PIPEREAUT, M. and VILA, A. "Etude sur la Fabrication et l'Utilisation du Sulfure de Zinc." (*Bull.* Soc. d'Encouragement pour l'Ind. Nat., Nov., 1909; 25 pp.)

Primrose, J. S. G. "Notes on the Production of Pure Spelter." (Paper before the Inst. of Metals, Oct. 14, 1909; 20 pp.)

Snyder, F. T. "Electric Zinc Smelting." (*Mex. Min. Journ.*, Nov, 1909; 1½ pp,)

Stöger, W. "Electrolytic Recovery of Zinc." (*Min. Journ.*, Jan. 30, 1909; ⅓ p.)

Stöger, W. "Electrolytische Zinkgewinnung." (*Oest. Zeit. f. B. u. H.*, Jan. 2, 1909; 4 pp.)

Taylor, James M. "A Rapid Method for the Determination of Zinc in the Presence of Iron." (*Journ.* Soc. Chem. Ind., Dec. 31, 1909; 1 p.)

Voigt, K. "Ueber die Bestimmung des Zinks und die Anaylse von Zinkerzen." (*Zeit. f. angew. Chem.*, Nov. 19, 1909; 4½ pp.)

White, Douglas. "The Zinc Mines of Southern Nevada." (*Proc.* Am. Min. Congress, 12th Annual Session, 1909; 11 pp.)

Wittich, L. L. "The Mining of Oxidized Zinc Ores in Southwestern Missouri." (*Mines and Minerals*, Dec., 1909; 1 p.)

New Patents.

Alloys.—Process of Making Alloys of Zinc with Copper. Sterling Elliott, Newton, Mass. (U. S. No. 927,843; July 13, 1909.)

Condenser.—Woolsey M. Johnson, La Harpe, Kans., assignor to The Continuous Zinc Furnace Company, Hartford, Conn., a Corporation of Connecticut. (U. S. No. 933,843, Sept. 14, 1909.)

Distillation Furnace.—Woolsey M. Johnson, Hartford, Conn., assignor to the Continuous Zinc Furnace Company, Hartford, Conn., a Corporation of Connecticut. (U. S. No. 920,473; May 4, 1909.)

Electric Furnace.—Electric Furnace for the Continuous Extraction of Zinc from its Ores. Eugène F. Cote and Paul R. Pierron, Lyon, France. (U. S. No. 944,-774; Dec. 28, 1909.)

Electrolytic Recovery of Zinc from Solutions of Zinc Sulphate.—Victor Engelhardt and Max Huth, Charlottenburg, Germany, assignors to Siemans & Halske, Aktiengesellschaft, Berlin, Germany, a Corporation of Germany. (U. S. No. 935,250, Sept. 28, 1909.)

Furnace.—Revolving Furnace for Volatilizing Zinc Ores. Harry H. Hughes, Springfield, Mo. (U. S. No. 920,143; May 4, 1909.)

Galvanizing.—Method of Galvanizing. George L. Patterson, Thomas L. Mornes, and Carl H. Zieme, Newcastle, Penn. (U. S. No. 928,398; July 20, 1909.)

Ore Treatment.—Process of Treating Zinc-Lead Ores. Frederick T. Snyder, Oak Park, Ill., assignor, by mesne assignments, to Electric Metals Company, Chicago, Ill., a Corporation of West Virginia. (U. S. No. 933,133, Sept. 7, 1909.)

Process of Treating Zinc.—Salomon Frank, Frankfurt-on-the-Main, Germany. (U. S. No. 935,900, Oct. 5, 1909.)

Recovery of Zinc Compounds.—Method of Recovering Zinc Compounds and Ammonia from Byproducts of Galvanizing. Elias G. Pearlman and Martin M. Pearlman, Philadelphia, Penn. (U. S. No. 919,375, and 919,376; April 27, 1909.)

Retort Filling.—Apparatus for Filling Zinc-Retorts with Granular Material. John D. James, Pulaski, Va. (U .S. Nos. 936,245, Oct. 5, 1909.)

Smelting.—Process of Smelting Zinc Ores. Anson G. Betts, Troy, N. Y. (U. S. No. 918,648; April 20, 1909.)

Zinc Dust.—Manufacture of Zinc-Dust. Sherard O. Cowper-Coles, London, England. (U. S. No. 623,411; June 1, 1909.)

Zinc Oxide.—Method of Making Zinc Oxide. Louis S. Hughes, Joplin, Mo., assignor to Picher Lead Company, Joplin, Mo., a Corporation of Missouri. (U. S. No. 920,337; May 4, 1909.)

Zinc Oxide.—Method of Manufacturing Zinc Oxide. Louis S. Hughes, Joplin, Mo., assignor to Picher Lead Company, Joplin, Mo., a Corporation of Missouri. (U. S. No. 920,336; May 4, 1909.)

Zinc Oxide.—Process for the Preparation of Zinc Oxide for Reduction. Herman Pape, Hamburg-Billwarder a Bille, Germany. (Brit. No. 5293 of 1909.)

NOTES ON THE PRACTICE OF MINING.

By Henry Lloyd Smyth.

The year 1909 was noteworthy for the publication of two important books on mining, namely, H. C. Hoover's "Principles of Mining" and J. R. Finlay's "Cost of Mining." The authors are engineers of wide experience both in the examination and in the operation of mines, and they have performed a great service in giving the results of their experience to the world. The books are thoroughly modern, and are the products of acute and vigorous minds, well stored with facts derived from personal experience, and deal with mining problems in fresh and independent ways.

H. C. Hoover's "Principles of Mining."

The first six chapters deal with the various factors which enter into mine valuation, and this part of the book, which is perhaps the most valuable, does not deal directly with mining practice. Of the remainder of the book chapters VII to XI inclusive are devoted to development, stoping, and supporting excavations, and chapters XII to XIV to mechanical equipment. Chapter XV deals with the ratio of output to the mine, chapters XVI to XVIII with administration, while chapter XIX discusses the risks in mining investments, and chapter XX the mining engineering profession. The following comments cover mainly chapters VII to XI.

Under development the author includes both exploration or the search for ore underground, and development proper, or the establishment of the openings necessary for its extraction. The location of shafts, and the factors governing the choice in inclined deposits between vertical shafts and inclined shafts (when the topography, property boundaries, depth of surface cover, and attitude of the deposit permit a choice) are discussed rather elaborately and in the main satisfactorily. However, his conclusion that vertical shafts must be located in the hanging, if the deposit dips at all, is too sweeping, for if the deposit is large and the ore soft, subsidence is inevitable and is practically certain sooner or later to result in the loss of a shaft so situated. Again, it would seem that Mr. Hoover attaches too little importance to the exploratory value of an inclined shaft sunk on the vein.

Where the deposit is inclined and the choice free between the vertical and inclined shaft, the determining factors, according to Mr. Hoover, are the relative cost of sinking and drifting and the relative operating cost. He illustrates the relative cost of sinking and crosscutting by a numerical example, in which he works out for each shaft the total cost of development to a depth of 1500 ft., for various angles of dip of the vein between 80 and 30 deg., assuming the vertical shaft to cut it (the most favorable case) at a mean depth of 750 ft. Assuming the cost per foot of sinking to be the same in the two cases, namely, $75, and the cost of crosscutting $20 a foot, he shows an advantage in favor of the inclined shaft which increases rapidly as the angle of dip diminishes. This example is unfair to the vertical shaft for two reasons. In the first place, Mr. Hoover assumes that there are no crosscuts from the inclined shaft, although elsewhere stating that a location in the footwall is generally the best for an inclined shaft. Secondly, by assuming a constant stoping height on the vein, he diminishes the lift interval as the angle of dip diminishes, and so increases the number of crosscuts as their length increases. For example, the number of crosscuts to a vein with a dip of 80 deg. is only 11, and the level interval is about 125 ft., while if the dip of the vein is 30 deg. the number of crosscuts is increased to 23 and the level interval is diminished to 62 ft. Now in practice a vein with a 30-deg. dip undoubtedly would not be opened by more crosscuts than a vein with a dip of 80 deg., but on the contrary probably by fewer, the block of ground, if the stoping height were too great being cut up into the same number of units by intermediate or sublevels. As a result of these assumptions, the reader might infer, that for a constant lift interval the comparison between the vertical shaft and the inclined shaft became more and more unfavorable to the former as the angle of dip diminished, whereas the contrary is really the case. Therefore, the conclusions from this numerical example are so misleading and the boundary between the fields in which one or the other is the cheaper is left so ill defined, that it seems desirable to present a general solution of the problem.

Comparison of the cost of developing an inclined vein to any level by an inclined shaft and by a vertical shaft.—Case I. The inclined shaft is sunk in the vein or in the footwall. The vertical shaft is sunk in the footwall starting on the surface at the same point as the inclined shaft.

Let θ be the angle of dip of the vein and of the inclined shaft (assumed to be constant), b the vertical distance in feet between levels, l the cost per foot of sinking the inclined shaft, l' the cost per foot of sinking the vertical shaft, and m the cost per foot of crosscutting. Then the length of the incline per lift $= \frac{b}{\sin\theta}$ and the length of crosscut from the vertical shaft to the incline at the first level $= \frac{b}{\tan\theta}$. The total footage sunk and driven to any level is given in the accompanying table:

DISTANCE SUNK AND DRIVEN TO DIFFERENT LEVELS.

Number of Level.	Inclined Shaft.	Vertical Shaft.	
	Feet Sunk.	Feet Sunk.	Feet Driven.
1st	$\frac{b}{\sin\theta}$	b	$\frac{b}{\tan\theta}$
2nd.	$\frac{2b}{\sin\theta}$	$2b$	$\frac{3b}{\tan\theta}$
3rd.	$\frac{3b}{\sin\theta}$	$3b$	$\frac{6b}{\tan\theta}$
nth.	$\frac{nb}{\sin\theta}$	nb	$\frac{n(n+1)b}{2\tan\theta}$

The total cost of development to any level n is, in the inclined shaft $\frac{nbl}{\sin\theta}$ and in the vertical shaft $nbl' + \frac{n(n+1)bm}{2\tan\theta}$. By making these two costs equal, and solving for n we may find the level at which the choice between the two methods of development becomes a matter of indifference, as far as initial cost is concerned.

$$\frac{l}{\sin\theta} = l' + \frac{(n+1)m}{2\tan\theta}; \frac{l}{\sin\theta} - l' - \frac{m}{2\tan\theta} = \frac{nm}{2\tan\theta}; n = \frac{2l - 2l'\sin\theta - m\cos\theta}{m\cos\theta}$$
$$= \frac{2(l - l'\sin\theta)}{m\cos\theta} - 1.$$

If $\theta = 60$ deg., $l = l' = \$75$ and $m = \$20$, then $n = \frac{2(75 - 75\times 0.866)}{10} - 1 = 1.01$.

With one level (regardless of the lift interval) the advantage in cost would rest with the vertical shaft; for two levels or more with the inclined shaft.

If $\theta = 30$ deg., the other constants having the same value as in the first example, $n = \frac{2(75 - 75\times .5)}{14} - 1 = 4.3$. That is the financial advantage in favor of the vertical shaft extends to greater depth as the angle of dip diminishes, the lift interval remaining unchanged.

Case II. The inclined shaft is sunk in the vein. The vertical shaft starts in the hanging wall, intersects the vein at half the total depth, and then continues in the footwall to the total depth.

This case is the most favorable for the vertical shaft for two reasons: Below the point of intersection, the situation is the same as in Case I. Above the point of intersection the situation is more favorable than in Case I because the longest crosscut (here falling at the surface) is omitted. The net result in comparison with Case I is to more than double the number of the levels at which the two methods of development stand on a financial equality. If for the sake of simplification the cost per foot of sinking the inclined shaft and the vertical shaft be made equal, the number of levels at which the cost of development becomes equal in the two cases is given by the equation

$n=\frac{4l}{m}(\sec\,\theta-\tan\,\theta)$. Our numerical examples become for $\theta=60$ deg., $n=\frac{4\times75}{20}\,(2-1.732)=4.020$; and for $\theta=30$ deg., $n=\frac{4\times75}{20}\,(1.155-0.577)=8.67$.

It may be remarked that the cost per foot for sinking inclined shafts is probably greater in most cases than for vertical shafts under the same breaking conditions. The cost is practically the same for steep inclinations, but increases as the inclination diminishes until the point is reached where the bottom (or breast) is partly exposed after the blast, permitting the new round of holes to be started before the muck from the last round is cleaned up. From this point on the cost of sinking an incline in dry ground more and more closely approximates that of drifting.

From the standpoint of capacity and operating cost the advantage is altogether with the vertical shaft, and this advantage may become decisive of the whole question when the output of the mine is likely to crowd the shaft or the incline is located in any but the firmest ground. The direct cost of maintenance of an incline in bad ground is heavy, and the indirect cost may be heavier, due to diminished capacity arising from the necessity for constant repairs.

Still a third consideration which must enter into the decision is not mentioned by Mr. Hoover. This is the time necessary for the total development on the two plans, as well as the time necessary for opening a new level in a going mine. This last is of special importance in operations on narrow veins, where the amount of ore tributary to a level is small, and consequently opening in depth is constantly in progress. The essential element in the problem is the relative speed of sinking and drifting. It is probably not far out of the way to say that under the average conditions presented by going mines the rate of drifting is about twice that of sinking. Making this assumption and representing the number of feet than ean be sunk per month by S, it is easy to adapt to the eomparison of time the formulæ already used in diseussing eost.

Case I. The time required to develop a deposit to n levels by an inclined shaft would be $\frac{nb}{S \sin \theta}$ and for sinking a vertical shaft and drifting, starting at the same point at the surfaee as with the inelined shaft, $\frac{nb}{S}+\frac{n\,(n+1)\,b}{4S \tan \theta}$

The level at which the time required by the two methods would be equal may be derived from the equation $\frac{nb}{S \sin \theta}=\frac{nb}{S}+\frac{\mathrm{n}\,(n+1)b}{4S \tan \theta}$; $\frac{1}{\sin \theta}=1+\frac{n+1}{4 \tan \theta}$; $n=4\ (\text{see}\ \theta-\tan\ \theta)-1$.

For less than n levels, the vertical shaft gives the quicker development and vice versa.

If $\theta=60$ deg., $n=4(2-1.723)-1=0.072$

If $\theta=30$ deg., $n=4(1.155-0.577)-1=1.312$

Case II. To open the nth level from the next level above requires for the inclined shaft a time equal to $\frac{b}{S \sin \theta}$ and for the vertieal shaft, $\frac{b}{S}+\frac{nb}{2S \tan \theta}$

The level at which these times are equal may be found by solving the equation, $\frac{b}{S \sin \theta}=\frac{b}{S}+\frac{nb}{2S \tan \theta}$; $n=2\ (\text{sec}\ \theta-\tan\ \theta)$. If $\theta=60$ deg., $n=0.536$; and if $\theta=30$ deg., $n=1.156$.

Therefore, in Case II, for angles of dip down to 30 deg., the advantage is altogether with the inelined shaft.

In chapter VIII Mr. Hoover gives a brief but valuable diseussion of the eomparative merits of the cireular and reetangular seetion for shafts at metal mines, and states elearly the reasons why the latter is generally to be preferred. He omits, however, one great advantage which the shaft of eireular seetion with masonry lining possesses, namely, that it may be made fireproof. In spite of its greater first eost this has been the reason for the seleetion of the eireular section with conerete lining for two shafts now being sunk in the Lake Superior iron region. Both of these shafts, however, are to have a long life.

On page 75 Mr. Hoover is in error in stating that any arrangement of eompartments other than side by side is impossible in inclined shafts. At the Ashland mine on the Gogebie range in Michigan, shaft No. 9, which is inclined at 60 deg. from the horizontal, has two skip roads carried on a heavy timber, parallel with the wall plates, and has three compartments under them along the foot-wall. These compartments are used for pipes, ladders and for a counterweight to the cage. This shaft has been in commission for several years, and the location of the hoisting compartments on the hanging has given no trouble.

In chapter IX Mr. Hoover discusses stations, crosscuts, levels, winzes, and raises. Under the subject of stations he is mistaken in stating that hoisting in skips makes underground pockets or bins necessary. Unquestionably they are highly desirable in order to separate tramming from hoisting, and to give the skips despatch, but the cars not only may dump directly into the skips with ore of any character, but in America, at least, they generally do so, when the ore is sticky and liable to pack and hang in a pocket.

In enumerating the factors which govern the interval between levels, Mr. Hoover omits the most important of them all, namely, output or the intensity of production desired. Evidently for any given vertical depth, the closer together the levels the more men we can put into the ground, and the more rapidly we can extract it.

Mr. Hoover's remarks on the untrustworthiness of the sample supplied by the diamond drill in the case of metallic deposits are brief and to the point. In truth the diamond drill is both a sampling tool and a surveying instrument, and in both capacities it has its limitations. The value of the sample supplied by the core and cuttings (if the latter are uncontaminated by material from higher up) depends on the uniformity of the ore, i.e., on the mass of which they may fairly be regarded as representative. To know where the sample comes from we need to know not only its distance down the hole, which is always measurable, but in addition the deviation of the hole from the line in which it started, and this is usually impossible. It is true that the dip of the hole at any point may easily be determined within a degree, but no satisfactory means has yet been devised of obtaining its azimuth.

In chapter X Mr. Hoover discusses stoping, but his diagrams illustrating the placing of holes to break ground in overhand and underhand stopes, do not include certain modifications which occasionally have been brought about in practice by the growing employment of the hammer drill. Since this drill (without an air or water jet) drills only upper holes, the profile of back stopes in which it is employed sometimes becomes more like that of a series of inverted under-hand stopes into raises, than step-like with horizontal back.

Mr. Hoover well says that the distinction between over-hand and under-hand stopes no longer bears any necessary relation to the pointing of the drill holes. The terms now usually signify the general direction in which the attack on the block proceeds, whether from below upwards, or from above downwards. Among the various over-hand methods of attacking the block Mr. Hoover dwells particularly on the method of so-called rill stoping. This method was first described in English by J. R. Finlay[1] under whom it was independently worked out as the best solution of a mining problem which he encountered at Zaruma in Ecuador. Essentially the same method had previously been employed at the iron mines of St. Pierre d'Allevard in France, and perhaps elsewhere. In brief, Mr. Finlay had to deal with a vein of firm ore of moderate width, but with a bad foot-wall, and an insufficient timber supply. He put up a series of raises to the surface along the foot-wall. Then starting at the bottom of each raise the ground was beaten out lengthwise of the vein and towards the hanging in the form of a cone, and to a height to which experience showed that the foot-wall might prudently be left unsupported for a short time. Halfway between the raises the cones came together. After cleaning up the broken ore which was left at the foot of each raise for the men to stand on, waste rock from the surface was milled down the raises, and distributed itself in the empty stope. Standing on these cones the men took another slice off the back. This was followed by another installment of filling, and in this way, by alternate stoping and filling, the block of ground was worked out. This method possesses four great merits: (1) If the raises are close enough together, the waste rock for filling requires little handling at the surface, and practically none at all underground. (2) The filling piles up against the weak foot where it is most needed. (3) The holes are all wet or down holes. (4) The ore when broken runs or is easily moved down the sloping surface of the cone of waste to mills built up at the intermediate points of coalescence, and not much of it needs to be shovelled.

The method as described and figured by Mr. Hoover is essentially the same, except that mills are carried up through the cones of waste at intermediate points as well as at the bottom. In other words there are more mills than raises. This modification multiplies the points of attack and accelerates the working out of the block.

The term rill-stoping is apparently of Australasian origin, and is but little employed in this country, where the method is usually spoken of as diagonal back-stoping with permanent filling.

In chapter X, "Methods of Supporting Excavations," exception might be taken to Mr. Hoover's definition of a system of square-set timbers

[1] *Trans.* A. I. M. E., XXX, 254.

as a truss (since it has no tension and rarely any diagonal members). His general treatment of square sets is excellent. He points out that to oblique stresses an assemblage of square sets offers no resistance whatever, except the stiffness of the framed joints. The truth is that square sets are effective in holding up ground only when it tends to detach itself in comparatively small units, which bring mainly vertical pressure to bear on the timber. If general movement of the hanging and ultimate subsidence must be prevented, in the end large square-set stopes have to be filled. No doubt in such cases the question may well be asked, why not use a filling method at the start, and save the cost of timber?

In his excellent discussion of the method of mining the block by allowing the broken ore temporarily to accumulate under foot in order to give standing ground for the attack on the back, Mr. Hoover, by including it under methods of supporting excavation, would seem to exaggerate its importance as affording support for the walls. In fact, this method, as Mr. Hoover himself later points out, is not adapted to a vein with a hanging or foot, so heavy as to require much support, except in those cases in which the value of the ore would not be reduced unduly by dilution with waste dropping from the walls. Nor is the Baltic lode worked on this system. At all the mines on the Baltic lode the filling is permanent, and consists of waste picked out from the vein matter as it is broken in the stopes, supplemented where necessary by blasting in the wall rocks. Again, it is not necessary to the success of this method to draw off constantly the excess of broken ore from the bottom as is done at the Treadwell mines and elsewhere. In certain cases it is feasible to carry up mills through the broken ore through which the excess is taken care of, leaving the great mass undisturbed until the time comes to empty the stope.

In Australia this method is known as shrinkage stoping, a name whose fitness is not very apparent. It is difficult to see what it is that shrinks —not the broken ore, certainly.. In this country the method is generally referred to as temporary filling with ore.

Caving methods are passed over with a few words, because the class of deposits with which the book deals rarely occur in soft, uniform masses of sufficiently large horizontal section to be well adapted to these methods. It may be mentioned, however, that some of the new porphyry copper deposits of the West meet the requirements in almost ideal measure. Also it is not quite true, as the author states, that ore bodies to be adapted to this method "must start near enough to the surface that the whole superincumbent mass may cave and give crushing weight, or the immediate over-hanging roof must easily cave." An obdurate hanging or capping may successfully be dealt with, either by working out the upper slice on square sets until the timbers have taken weight, and then blasting them in, or by working it out in sections without timber, filling each with rock broken from the hanging. In both cases the aim is to obtain a cushion of broken rock thick enough to protect the men on the lower slices from the fall of large masses, until the capping is given sufficient span to bring about general subsidence.

J. R. Finlay's "Cost of Mining."

Mr. Finlay's book is a serious and philosophical discussion of the business of mining from a broad financial standpoint. The last eighteen chapters deal with coal and the common metals, and in them the author endeavors by analyzing the reports of typical mining companies to reach general conclusions concerning the cost of producing these substances. This work is well done, and one is at a loss to say what is most worthy of admiration, the author's wide personal knowledge of mining conditions, the acuteness with which he goes to the heart of his matter, the boldness with which he fills in or reconstructs imperfect or misleading reports, or the good judgment and discretion which he displays in dealing with delicate situations, in regard to which he has received confidential information. In these chapters he applies to concrete cases the principles which he has developed in the first three chapters. While even these earlier chapters do not deal directly with mining practice in the strict sense, yet they contain matter which may profitably be noticed here.

In chapter I on the "Value of Mining Property," Mr. Finlay, after pointing out that its value depends on the cost of the article produced and the price for which it is sold, goes on to discuss the general relation of cost to price. One of the most valuable parts of this discussion is his illuminating exposition of the effect of high wages on the efficiency of labor. A high wage scale produces a flow of labor to the favored point just as a rise in the discount rate of the Bank of England attracts gold to London. A local oversupply of labor results, with consequent competition for the desirable job, and selection and elimination do the rest. The peculiar nature of a mining enterprise, namely that it is bound to terminate, and therefore that its returns should include paid-back capital as well as interest thereon, is strongly insisted on.

In chapter II on the "Factors Governing Variation in Cost," Mr. Finlay states the elements of cost as (*A*) the use of capital in acquiring the opportunity to mine, that is to say, the ownership of ground or leases; (*B*) the use of capital for equipping and developing a mine, and providing means for metallurgical treatment; (C) current operating costs. (A) he dismisses from consideration on the ground that the use of capital in this way is only a speculative anticipation of profits to be won by operating and confines his attention to (B) and (C). While admitting the fact that the nominal capitalization of many, perhaps a vast majority, of the mining undertakings in America bears no just relation to the cash actually disbursed in acquiring the mining opportunity, yet as far as the disbursements go, they must be paid for out of the product, and are an element in its cost. In certain cases they are a very important element in its cost. We have had two striking illustrations of this fact in this country, namely, in the anthracite region of Pennsylvania and in the Lake Superior iron region. In the development of these two great mineral fields the moment came when it was seen that their resources were not limitless. The opportunity existed for strong and conflicting interests to ensure themselves a long life and to prevent their rivals from doing the same by acquiring all the available territory. The resulting competition forced up prices, and mining opportunity for a long future was quickly secured in a few hands. The cost in interest and taxes for carrying these unproductive assets is borne by the public in the form of a very appreciable increase in the cost of anthracite coal and steel. For this no one, certainly no individual, is to blame. It is the inevitable result of our Anglo-Saxon practice of including in the ownership of the soil, the ownership of the underlying minerals.

However, there are two justifications for Mr. Finlay's course in omitting (A) from his calculation. The first is the extreme difficulty, in specific cases, of getting at the actual disbursements. The second is that for the man who buys an interest in a going mining enterprise—and it is this man whom Mr. Finlay has especially in mind—it is included in the price he pays for his stock.

The factors that produce variations in mining cost in different districts or countries, Mr. Finlay divides into two classes, namely, external and internal. Among the external conditions, he includes certain underground conditions, namely the hardness of the ground, the flow of water and underground temperature. It is difficult to see in what sense these conditions are external to the deposit. The discussion of the internal or inherent conditions is most interesting, especially as to the effect of homogeneity in the ore.

In chapter III Mr. Finlay discusses "Partial and Complete Costs," and this chapter is exceedingly valuable. Yet it must be said that there is a certain lack of clearness in his treatment of depreciation and maintenance. After some discussion and explanation he states that by depreciation he means the cost of current construction and improvements, in fact, maintenance. While it may be granted that in the long run, and for a bird's-eye view of a mining enterprise extending over a term of years—in short, for Mr. Finlay's purpose—depreciation is in a sense the equivalent of maintenance, yet in the current accounts of most mining enterprises, they are very different things. In a general way the maintenance items on a cost sheet represent actual disbursements for new construction, renewals, repairs, etc., while depreciation is a yearly reduction on the books of the valuation of the fixed assets. Unless total assets are to be reduced an equal sum must be withheld out of earnings to meet the cost of future construction, or of past construction carried in suspense accounts, or for some other purpose, and this is also called depreciation. In other words depreciation adds to quick assets, while maintenance reduces them and is, in fact, liquidated out of depreciation credits. In the long run maintenance and depreciation may amount to the same thing and probably do in most cases; however, the essential difference becomes striking in case the enterprise is suddenly wound up, or as not infrequently happens, when depreciation is used not solely for construction, but to acquire new property to take the place of a waning old property, and thus prolong the life of the whole undertaking.

Disasters in Coal Mines.

In 1909 the literature dealing with coal-mine disasters and their causes was large, but on the whole brought out nothing new. The reports of the Marianna explosion, of the two explosions at Lick Branch, and of that at Short Creek made it plain that they were caused, as most of these catastrophes are caused, by flagrant carelessness on the part of the men or the management, involving neglect of ordinary and well-understood precautions, or violation of rules or even of the law. The fire at the St. Paul mine at Cherry Hill, Illinois, was not caused by an explosion, and hence differed from most great disasters in coal mines. In fact, such a disaster might happen in any metal mine where inflammable substances are taken underground, where there is plenty of dry timber to burn, and the men on the spot lose their heads. The loss of life was undoubtedly enormously increased by failure to notify the men of the fire and get them out at once, and by the existence of an artificial ventilating system, which quickly distributed the smoke and products of combustion through the gangways and rooms.

After the Monongah catastrophe, in December, 1907, Le Comité Central des Houillères de France sent over a commission, consisting of M. Taffard, director of the experiment station at Liévin, and M. Pol

Dumaine, an engineer on the staff of the Compagnie des Mines d'Anzin, to investigate it. These gentlemen also included in the field of their labors the Darr mine and the Naomi mine, which had suffered from explosions, the first shortly after and the latter shortly before that at Monongah. The report of this commission, which is printed in *Annales des Mines* for November and December, 1909, is an extremely interesting document. As a result of their very detailed studies at Monongah, the commission came to the conclusion that the runaway trip at No. 6 slope was the cause of the disaster, a conclusion which a careful reading of their report shows to be clearly proved. In brief, they found that the explosion originated in No. 6 mine and not in No. 8, and that the foot of the slope where the cars piled up was the point from which the explosion traveled in all directions. The fact, which has been held almost unanimously by the American investigators and mine inspectors to indicate some point in No. 8 as the point of origin, namely, that the flame and blast issued from No. 8 slope before the smoke appeared at the mouth of No. 6, they explain by pointing out that No. 6 slope was practically blocked by the wreck.

The steps by which the course of the explosion was followed back to its source are of principal interest, and constitute a model of intelligent observation and discriminating reasoning which ought to be studied with the utmost care by American engineers. It would take too much space to give anything like a full account of the illuminating discussion of the criteria by which the direction of propagation was established. In brief, what may be called the coarser dynamic effects, such as the overturning of timber, blowing out of stopings, etc., are unreliable in a mine like the Monongah where the openings are so large and numerous, and so frequently connected, because secondary waves, in some cases even more violent than the first, frequently sweep the same road in reverse direction, and produce complication and confusion. Also the erosion of the angles of the coal exposed on the sides, so much relied on in this country for determining the direction of propagation, is frequently misleading, since it requires a certain minimum velocity and duration of high temperature for its production, and the secondary waves may be hotter as well as more violent than the original. The only certain guide is the coke crusts on the back of timber, on the side towards which the blast moves. These must be carefully discriminated from the dust prisms which face the blast, and which, being among the dynamic effects, may be due to the later waves. In fact, in some cases at Monongah, dust prisms were found superimposed on coke crusts. In making this discrimination in doubtful cases, the authors recognize the value of the chemical test, first suggested by Dr. J. A. Holmes, of the U. S. Geological Survey. The dust prisms are uniformly higher in ash than the coke crusts, due to the sorting action of the blast, as proved by controlled experiment at the Liévin station.

At the Darr mine the French commission had no difficulty in tracing the course of the explosion to its origin in No. 9 left butt entry off No. 27 face, thus confirming the conclusion reached by the bituminous mine inspectors two years ago. This entry was extended about 500 ft. west of No. 27, and from it four rooms had been started. About 100 ft. back from the face an explosion of exceptional violence had taken place, the general conditions recalling those found in the Lecœuvre road at Courrières. There were two dismembered bodies with the limbs thrown to considerable distances, a car had been blown to pieces, and fragments even of the wheels were scattered over a length of 100 ft. in the heading. While the primary cause may have been a gas explosion, for the heading was gaseous and the men used naked lights, or even a blown out shot, the authors incline to attribute it to an explosion of dynamite, which was used in the heading and which the men were accustomed to carry in their pockets together with caps and fuse.

The Naomi disaster, in the opinion of the French commission, was a gas explosion pure and simple, probably set off by naked lights in the return airway.

It is usually interesting and sometimes profitable to know what foreigners think of us and our ways. The report concludes with the following discreet and courteous paragraphs:

"At many points of our story the French reader must have been astonished at the practices permitted in the mines that we have visited—practices that we have described without comment. It must not be forgotten that from the point of view of safety American mines are in a very different condition from ours. There is no doubt that we in France are more on the lookout for safety than is the case in many other countries, but aside from this difference in temperament, there is a difference in history. Up to the present American mines have been relatively safe. They have been more like great underground quarries, well laid out for production, than mines as we ordinarily conceive them. Fire-damp has been rare. Dust has been absent in the case of many operations. The extension of the workings farther from the outcrop has resulted in increasing difficulty in ventilation, and at the same time has increased the gas given off. Furthermore, the increase of late years in mechanical undercutting has considerably increased dust. So the dangers which the American mines experience have perceptibly grown in the last few years.

"In the moral and social realm, as in the mechanical, there is inertia to be reckoned with. New regulations appear only some time after the causes that make them necessary. It may be said to the honor of American engineers that they do not seem slow in adopting necessary reforms."

Shaft Sinking.

The literature on shaft sinking in 1909 was not extensive. F. A. Adgate[1] described in detail the sinking of the Smith and Kidder shafts in the Swanzy district at Lake Superior. It will be recalled[2] that these two concrete drop shafts, the one rectangular, the other circular in section, were successfully ledged at 61 and 104 ft. respectively, and a water-tight joint with the rock made by the use of compressed air.

At the Morton mine near Hibbing, on the Mesabe range, a concrete drop shaft has been under way since October, 1908, and has not yet reached the ledge, which is found at a depth of about 190 ft. The construction of this shaft and the method of sinking it have been described by A. H. Fay.[3] The ground passed through consists of water-bearing sand and gravel with occasional beds of clay. The shaft is of circular section being 21 ft. in inside diameter at the bottom, with 4-ft. walls, making the outside diameter 29 ft.

Except as regards some details the construction of the shaft is the same as the Kidder, the only important variations being in the method of attaching the 12-ft. dredging well, and in the water holes. These last are 21 square openings 6x6 in. and about 3 ft. 10 in. apart, carried up through the concrete shell, and passing through the shoe below, where they are contracted so as just to permit a 2-in. pipe to pass near its cutting edge. In sinking, a 2-in. pipe was passed down through these openings and connected to a pump, in order to loosen up the sand ahead of the dredge by means of water jets.

The great difficulty with this shaft has been in getting the concrete structure down. Although heavily loaded with sand and pig iron it is reported to have hung at the depth of about 180 ft. for many months. Mr. Fay states that the contract price was approximately $500 a foot.

M. Jules Lombois described[4] the sinking of three shafts by the Campagnie des Mines de Béthune by the cementation process through water-bearing Cretaceous limestones to a depth of about 90 m. These sinkings were in progress at various times between 1904 and 1907, and thus partly antedated the sinking by cementation at Liévin.[5]

[1] *Proc.* Lake Superior Min. Inst., XIV, 55–70.
[2] *The Mineral Industry*, XVII, 897, 898.
[3] *Eng. and Min. Journ.*, LXXXVIII, 599–601.
[4] *Bull.*, Soc. Ind. Min., IX, No. 4; *Eng. and Min. Journ.*, LXXXVII. 653, 655.
[5] *The Mineral Industry*, XVII, 895, 896.

The method at the Béthune shafts differed in several particulars from that employed at Liévin. The chief points of difference were that no false bottom was used (since cementation was begun at the surface) and that the cement was injected by the positive pressure of a pump. In the first shaft the experiment was tried of injecting the cement while some of the holes were being drilled, but this does not seem to have worked well, as it was not employed in the later shafts. Trouble also arose at this shaft from the inequality in size of the ingredients of the cement, resulting in a sizing through the action of the current in the fissures in the rock. This led to imperfect setting. In the later shafts a cement ground especially fine was used.

The last shaft to be cemented, No. 7, gave somewhat more trouble, because it passed through ground fissured by subsidence, but in the end was successfully completed. The routine was to drill each hole to a depth of 5 m., then cement, then drill another 5 m. and so on. Toward the end of the work, when everything was progressing smoothly an advance of 5 m. was made in a day. The cementation was so complete that the flow of water at a depth of 87m. was cut down to less than half a gallon a minute.

This article gives an excellent description of the plant and the details of its operation, but no costs. It is to be regretted that the distance to which the cement traveled from the holes, and the percentage of open space in the rock could not have been determined. In the case of the first two shafts, which had an inside diameter of 5.2 m., four holes were sufficient to do the work. These were put down inside the neat line in the first shaft, but outside it in the second. The third shaft, which had an inside diameter of 8 m., had six holes all inside.

William Kelly has described[1] the method by which a concrete lining was put into a rock shaft at Norway on the Menominee range in Michigan. Concrete was decided on in order to make the shaft safe against fire, and to avoid the repairs to which timber is subject. The section of the shaft was circular in order to adapt it to concrete.

The circle, which is 14 ft. in inside diameter, is subdivided into seven compartments for a cage, for a six-ton skip, for a ladder road, for counterbalances for skip and cage, and one for general purposes. Steel sets placed 10 ft. 8 in. between centers carry the guides, collars, etc. The ladders are steel, and corrugated galvanized sheet steel is used for separating the ladder and skip compartments. The only timber in the shaft is the guides for the cage, which, since it carries men, is provided with safety catches. The concrete lining, which was not reinforced, had an

[1] *Proc.*, Lake Superior Min. Inst., XIV, 141–146.

average thickness of 19 in. and a minimum thickness of 6 in. This meant about 3 cu.yd. of concrete per running foot of shaft. The forms were of $\frac{1}{8}$-in. sheet steel.

The total costs were as follows: 1st section, surface to ledge, 62 ft., $104.01 per ft.; 2nd section, ledge to 7th level, 549.5 ft., $76.28 per ft.; 3rd section, 7th level to bottom, 85.84 ft., $87.19 per ft.

The excavation in rock from the 7th level up was effected in two stages, first by raising to the ledge from three points on the line of the shaft, and then by stripping down into the raise out to the final section. In this way no broken rock was hoisted through the shaft, and the cost was greatly reduced.

The cost of concreting alone cannot be determined precisely from Mr. Kelly's figures, but was not far from $30 a foot for the middle section, or about $10 a cubic yard.

R. H. Rowland described[1] the lining of an air shaft in Oklahoma with 6 in. of concrete, not reinforced. This shaft was sunk in black shale and was 9 ft. 6 in. in diameter. For a depth of 330 ft. the cost complete, including the cost of lining, is stated by Mr. Howland to have been $27.56 a foot.

[1] *Eng. and Min. Journ.*, LXXXVIII 359.

PROGRESS IN ORE DRESSING AND COAL WASHING IN 1909.

By Robert H. Richards and Charles E. Locke.

Crushing and Grinding.

Chili Mill vs. Stamps.[1]—The accompanying table compares five Chili mills with a combination of 25 stamps and two tube mills, working on average quartz at Pachuca, Mexico.

COMPARISON OF STAMPS WITH CHILI MILLS.

	5 Chili Mills.	25 Stamps-2-Tube Mills.
Capacity when crushing to 150 mesh....	100 tons	100 tons
Cost of mills and power plant...........	$24,000	$17,000
Weight of mills and power plant........	195 tons	127 tons
Power required........................	46 h.p.	95 h.p.
Wearing parts renewed................	Every 2 years	Every 3 months

The figures in the table are based on cost of ironwork without framing, as the latter would be about the same in either case. The tubes were 3.5x14 ft., and the stamps weighed 1050 lb. Among the points not covered in the table is head room, the required amount of which is much less with the Chili mill, thus giving greater latitude in choice of sites. Less actual ground space is also required. Supporting framework, building and erection costs, including a simple hand crane for the Chili mills, are about the same in either case, while depreciation, attendance (skilled as well as unskilled), accessory equipment, breakages and probable delays are all decidedly in favor of the Chili mill. The best feature of the stamp mill, its ability to withstand rough handling, is also possessed by the Chili mill. Neither over-feeding nor under-feeding has any effect on its continuous operation; these conditions merely reduce its capacity temporarily.

Cobbe-Middleton Grinding Pan.[2]—In the Kalgoorlie district, tube mills have largely replaced grinding pans, but at the Hainault mine, Messrs. Cobbe and Middleton are still using an improved form of pan. In this pan the muller is supported on a spindle and revolves in a fixed plane, while

[1] M. R. Lamb, *Eng. and Min Journ.*, LXXXVII, 1182; Abstr. in *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 151.
[2] *Min. Mag.*, I, 213.

the pressure between the shoes and the dies is obtained by weighted levers that press the loosely mounted pan upward. The pan bed is held in guides, in which it may slip up and down. Levers are so arranged that the pressure of grinding is adjustable and by means of a hand wheel the pan bed may be forced downward so that the dies are out of contact with the shoes. The advantage claimed is uniform grinding pressure. There are radial fillets on the under side of the shoe and on the top side of the die to help the circulation of the pulp. The shoes and dies are also corrugated on their outer edges. The wear of shoes and dies costs 3.5c. per ton ground. The screen surrounding the pan is 15 or 16 mesh and, owing to the angle at which the pulp strikes it, the product is equivalent to 40 mesh. At the Hainault, 5 pans, requiring 7 h.p. each, grind the ore coming through 8 mesh from 40 stamps, down to 40-mesh size. Amalgamation is carried on in the pan.

DETAILS OF STAMPS IN MODERN CYANIDE MILLS.

Name of Mill.	Number of Stamps.	Weight of Stamps, lb.	Height of Drop, In.	Drops per Minute.	Duty per 24 Hours. Tons.	Screen Mesh.	Life of Die, Days.	Life of Shoe, Days.	Life of Screen, Days.
Colorado	60	1050	6 to 8	100	3.8	26	50	112	3
Combination	20	1200	6	108	4.5	....	74	96	10
Desert	100	1050	6	104	4.79	12–14	59	76	30
Dos Estrellas No. 2	120	1250	6.5	102	4.2	16, 26	65	65	2 to 5
El Oro	100 100	1000 1150	7.5 6	104 102	3.75 4.00	35	....	....	....
Goldfield Consolidated	100	1050	....	108	....	16	....	....	....
Guanajuato Consolidated	80	1050	7.5	104	3.6	50	....	....	30–35
Guanajuato Development (Pinguico)	40	1050	6.5	104	6.25	2, 4, 8	....	....	....
Guanajuato Reduction	160	1050	7.5	100	3.1	26	....	....	....
Homestake	1000	900	10.5	88	4.0	No. 8slot	....	....	....
Loreto	40	1050	....	106	3.0	16	....	....	....
Montana-Tonopah	40	1050	7	100	3.5	20	....	....	....
North Star	80	1050	8	96	3.1	20	....	....	25
San Francisco	30	1050	6.5	104	....	20	....	....	....
Standard	20	1000	4 to 6	96–106	2.3	30	57	122	55
Veta Colorada	100	1050	7	....	....	8–10	....	....	....

Power for Crushing Machinery.[1]—The following approximate data are given in a catalog issued by the General Engineering Company, of Salt Lake City, for use in making preliminary estimates only. *Blake breaker:* 7x10 in., 8 h.p.; 9x15, 15 h.p.; 10x20, 20 h.p.; 15x24, 30 h.p. *Dodge breaker:* 4x6 in., 2 h.p.; 7x10, 7 h.p.; 11x15, 15 h.p. *Gates breaker:* D style, No. 1, 10 h.p.; No. 2, 15 h.p.; No. 3, 25 h.p.; No. 4, 30 h.p.; No. 5, 40 h.p.; No. 6, 60 h.p.; No. 7, 125 h.p.; No. 8, 150 h.p. *Gravity mills:* 10-stamp, 8-in. drop, 90 per min., 750-lb., 15 h.p.; 850-lb., 17 h.p.; 950-lb., 19 h.p.; 1000-lb., 20 h.p. *Tube mills:* 5x14-ft., 30 h.p.; 5x22 ft., 70 h.p.; 4x20 ft., 50 h.p. *Chili mills:* 4-ft., 6 h.p.; 5-ft., 12 h.p.; 6-ft., 25 h.p. *Huntington mills;* 3½-ft., 4 to 5 h.p.; 5-ft., 6 to 7 h.p.; 6-ft., 8 to 10 h.p.

[1] *Mines and Minerals*, XXX, 87.

Cornish rolls: 12x20-in., 12 h.p.; 14x27, 16 h.p.; 16x36, 25 h.p. *Sample grinders:* No. 1, 3 h.p.; No. 2, 4 h.p. *Amalgamating pans:* 5-ft., 4 h.p.; 8-ft., 6 h.p. *Grinding pans:* 5-ft., 6 h.p.; 8-ft., 9 h.p.

Crushing with Stamps and Tube Mills.[1]—A review of 19 cyanide mills in the United States and Mexico affords the following conclusions: Jaw breakers are more favored than gyratory breakers; Dodge breakers are used in only one mill; stamps are almost universal for fine crushing. The stamp practice is shown in the table on the preceding page.

Bryan, Huntington and Chili mills are used in a few plants as intermediate grinders, following the stamps. Tube mills are being used more and more for fine grinding. The practice is shown in the accompanying table:

DETAILS OF TUBE-MILLS IN MODERN CYANIDE PLANTS.

Name of Mill.	Make	No.	Speed.		Speed. R.P.M.	Capacity per 24 Hours, Tons.	Power H.P.	Pebbles.		Lining.	
			Diameter. Ft.-In.	Length. Ft.-In.				Kind.	Consumption, per ton ore lb.	Kind.	Consumption, lb.
Combination	Abbé	1	4	16	26	30	16	Danish	2.4	Silex	1.2
	Abbé	1	4	12	26	24	14				
Dos Estrellas	A-C	5	5	24	26	121	55	Quartz	....	El Oro	0.84
El Oro	Abbé	2	4 6	19 6	31	100	50	....	8.4	El Oro	1.0
	Krupp	1	3 11	19 6	31	110	48				
	Krupp	1	4 11	23 0	25	190	80				
	Krupp	1	4 11	26 0	27	275	87				
Goldfield Consolidated	Gates	6	5	22	......	....	......	....	....	....	....
Guanajuato Reduction	Abbé	2	4 6	20	......	80	43	Danish	0.75	Silex	....
Loreto	Abbé	2	....	....	......	....	......	....	....	....	....
	Krupp	1	....	....	......	....	......	....	....	....	....
Montana-Tonopah	Gates	2	5	22	27	52	42.5	....	2.22	Silex	....
North Star	Abbé	1	4 6	20	20	30	16	Quartz	40	Chilled Iron	....
San Francisco	Krupp	....	4 3	13 1	29	....	......	Danish	....	El Oro	....
Standard	Gates	1	5	22	24	125	50	Danish	3.0	Soft Steel	0.5
Veta Colorada	....	5	5	14	......	....	......	....	....	Chilled Steel	....

For classifiers, V and conical spitzkasten and hydraulic cone classifiers are used. The Dorr mechanical classifier is also favored. Amalgamation is in vogue wherever the recovery of gold warrants its use. Tables alone are used in five mills, vanners alone in two mills and vanners and tables together in six mills. The concentration may recover high-grade product suitable for smelting, it may remove cyanicides, or it may save coarse gold which would not be dissolved by cyanide.

Concentrating Machines and Processes.

Sorting on the Rand.[2]—With the ores of the Rand considerable waste

[1] S. F. Shaw. *Bull.*, 31, A. I. M. E., July, 1909, 531. *Min. Journ.*, LXXXVII, 8, 82, 125, 172. *Min. Wld.*, XXXI, 315, 371.
[2] L. D. Huntoon. *Eng. and Min. Journ.*, LXXXVIII, 1069.

material, amounting to between 10 and 80 per cent., is hoisted. It is not desirable to remove this waste by sorting underground, owing to the losses which occur from the poor light and the fines. The usual practice is to dump the ore from the hoisting skip into bins of sufficient capacity to allow all of the sorting to be done in the day time. From the bins it is transported to grizzlies sloping 40 to 45 deg. These are placed side by side and are from 13 to 15 ft. long and about 3 ft. wide. At the Ferreira the total width is 70 ft. and will handle 1000 tons per day. The oversize above one inch, 70 per cent. of the total, is delivered upon the sorting floor or picking tables where it is thoroughly washed before sorting. The Ferreira sorting floor is 11x70 ft. covered with ½-in. steel plate.

For picking tables, the shaking table and the conveying belt are not favored. The circular table of annular form, inside diameter 17 ft., outside diameter 25 ft., has been brought up to a state of high efficiency on the Rand. It has a steel surface slightly inclined toward a launder on the outer edge to receive the wash water. The speed is about 0.75 r.p.m., the table being driven by a rack and pinion from below. Waste is picked out and the residue is removed by a plow. In an improved form, the table is in two steps; the ore is delivered to the lower level and the waste, as it is picked out, is placed on the upper level where it can be inspected before it is finally scraped off. In some cases a double set of grizzlies is used, making a two-stage sorting process, delivering two sizes to the pickers, one size above 3 in. and the other size between 3 and 1 in. Rock breakers have replaced hammers for reducing the ore.

The Ferreira company has studied the sorting question very carefully and in place of the old 2¼-in. spaces in the grizzlies, where 25 per cent. of waste was discarded at a cost of 12c. per ton milled, it now uses 1-in. grizzly spaces, which increases the waste discarded to 35 per cent. and the cost to 37c. It is figured that a still further reduction to ¾ in. would yield a further profit of $1200 per month. The cost of hand sorting, averaged for 4 years, is 21c. per ton milled, or 64c. per ton of waste sorted. The effect of increased sorting, in increasing the capacity of the mill and reducing costs, is well shown in the three accompanying tables. The first shows Ferreira costs over a period of years and indicates that it is cheaper to sort out waste than it is to run it through the mill. The second table shows a gradual increase in the quantity of ore milled and shows that the value of the waste discarded is less than that of the mill tailing. The third table shows the savings that have been made by sorting.

TABLE I. COSTS PER TON MILLED.

	1889.	1902.	1903.	1904.	1908.
General	....	....	....	$0.031	
Transportation	$0.067	$0.093	$0.094	0.059	$0.180
Crushing	0.072	0.109	0.094	0.086	
Elevating	....	0.083	....		....
Stamp milling	0.535	0.820	0.680	0.536	0.400
Retorting	....	....	....	0.014	....
Conveying and classifying	....	....	....	....	0.094
Tube milling	....	....	....	....	0.133
Concentrating	0.207	0.329	0.113	....	....
Cyaniding sands	0.580	0.688	1.100	0.890	0.480
Cyaniding slimes	0.474	0.539			
Total	$1.935	$2.661	$2.081	$1.616	$1.287

TABLE II. RESULTS FROM PRELIMINARY HAND SORTING.

Period Ending.	Ore Sent to Rock House, Tons.	Hand Sorted Waste.		Ore Milled, Tons.	Assays, in Dollars.			Increased Value.	
		Tons.	Per Cent.		Ore Mined.	Waste Rock.	Ore Milled.	Dollars.	Per Cent.
September, 1891	42,054	....	....	42,054	....	....	....	....	....
March, 1892	24,567	....	....	24,567	....	....	....	....	....
March, 1893	57,794	9,017	15.6	48,777	19.38	0.78	22.69	$3.31	17.08
March, 1894	70,212	22,999	32.8	47,213	21.10	0.94	30.72	9.62	44.40
December, 1894	66,543	29,759	44.7	36,784	19.33	1.06	33.76	14.43	74.66
December, 1895	99,689	38,435	38.5	61,254	19.42	0.97	30.98	11.56	59.49
December, 1896	178,918	58,156	32.5	120,762	17.26	1.06	25.05	7.79	45.15
December, 1897	186,922	61,596	32.9	125,326	17.35	0.49	25.04	7.69	41.40
December, 1898	219,940	88,227	40.1	131,713	13.47	0.83	21.93	8.46	62.85
December, 1899	141,858	46,690	32.9	95,168	14.76	1.08	21.64	6.88	46.60
War Period:									
December, 1902	74,511	15,079	20.2	59,432	12.68	1.34	15.56	2.88	22.71
December, 1903	200,581	48,750	24.3	151,831	11 40	....	15.30	3.90	33.20
December, 1904	286,413	65,606	22.6	220,808	11.10	0.98	14.20	3.10	27.90
December, 1905	309,316	71,816	23.3	237,500	....	....	....	....	....
December, 1906	308,715	56,090	18.2	252,625	....	....	....	....	....
December, 1907	306,252	37,649	12.3	268,603	....	....	....	....	....
December, 1908	337,292	46,522	13.7	290,770	10.90	1.40	12.43	1.53	14.00
Totals	2,911,577	696,390	23.9	2,215,187					

TABLE III. TOTAL DIRECT SAVING DUE TO SORTING.

Year.	Savings on Milling Cost.				Savings on Tailings Loss.				Total Savings.
	Cost per Ton.		Saving per Ton.	Total for Year.	Loss per Ton Milled.	Assay of Sorted Waste.	Saving per Ton Sorted.	Total for Year.	
	Milling.	Sorting.							
1893	....	....	....	....	....	$0.78	....	....	$33,200
1894	12 mont	hs end	ing Marc	h.	....	0.94	....	....	95,600
1894	9 mont	hs endin	g Decem	ber.	....	1.06	....	....	71,500
1895	....	....	....	....	....	0.97	....	....	112,000
1896	....	....	....	....	....	1.00	....	....	136,000
1897	....	....	....	....	....	0.49	....	....	117,000
1898	....	....	....	....	....	0.83	....	....	204,000
1899	$1.93	$0.39	$1.54	$72,000	....	1.08	....	$32,000	104,000
1902	2.65	0.70	1.95	29,400	....	1.34	....	14,300	43,700
1903	2.08	0.72	1.36	66,500	$2.18	0.93	$1.25	61,000	127,500
1904	1.62	0.72	0.90	59,000	1.95	0.98	0.97	63,500	122,500
Total	....	....	....	$226,900	....	....	....	$170,800	$1,167,000

Bunker Hill Screen.[1]—This consists of a conical revolving screen mounted on an axis inclined at an angle of 45 deg. Surrounding the screen is an iron hopper for catching the undersize. The whole arrangement resembles very much a funnel tipped over at 45 deg. The material to be screened is fed on the inside of the screen a little below the meridian line and falls in the same direction as the travel of the screen. Two spray pipes are used and material passing through the screen is discharged through a hollow shaft connecting with the bottom of the hopper.

Impact Screens at Utah Copper Company's Mill.[2]—Originally the units of this mill contained trommels, equivalent to about 6 mesh, and stationary screens, equivalent to about 20 mesh. These did not prove satisfactory, and after numerous tests it was decided to install Impact screens. The advantages obtained are as follows: The capacity of each unit has been increased from 500 tons to 600 tons per day, the tables handling the increased feed by reason of its closer sizing; the saving of about one-fourth of the water used by the trommels is effected by running the four coarse Impact screens, the crushing rolls, and the elevator dry, this also increasing the life of the elevator by several months; the expense for screen cloth is also reduced, the cost of renewals being in the ratio of $128 for the trommels to $14 for the Impact screens.

Washer for Low-Grade Gold Ores.[3]—The soft saprolitic gold ores of North Carolina contain considerable clay and the ordinary methods of sluicing and amalgamation do not save the gold. A form of log-washer known as the Modern pulverizer and concentrator has been patented to work on these ores, and is successful in solving the problem. Each unit of the machine consists of troughs of boiler plate containing a revolving cylinder fitted with heavy cast-iron arms set helically. The discharge end is raised 6 in. higher than the feed end. Between the first part, which is 18 ft. long, and the second part, which is 12 ft. long, is a trommel whereby the nearly barren quartz stones are taken out and delivered to a belt conveyer which carries them to a riffled sluice box outside the building, 12 in. wide and about 200 ft. long. The discharge from the second half is likewise screened in a trommel and the oversize delivered to the same sluice box. The undersize of the second screen passes through special riffled sluices about 4 ft. wide and 8 to 16 ft. long and afterward flows into the 200-ft. sluice outside the building. The steel troughs of the log-washer are about 2 ft. wide and $2\frac{1}{2}$ ft. deep. The logs are made of 8-in. steel pipe. The greatest wear comes on the paddles, which

[1] *Min. Sci.*, LIX, 234.

[2] H. B. Lowden. *Eng. and Min. Journ.*, LXXXVII, 992; *Min. Sci.*, LIX, 311; *Electrochem. and Met. Ind.*, VII, 32; *Min. Wld.*, XXX, 630.

[3] J. H. Pratt and E. W. Lyon. *Eng. and Min. Journ.*, LXXXVII, 293, 935.

are $5\frac{1}{2}$x$2\frac{1}{2}$x2 in., are made of east-iron, and last 4 to 6 weeks. There are 48 paddles in the 18-ft. trough. There is about 4 in. elearance between the tips of the paddles and the bottom of the trough, whieh reduees the wear on the trough and helps the gold to settle to the bottom. The troughs are cleaned about twiee a week, through an opening in the bottom, using a hose, and the gold is reeovered by hand panning. The riffled sluiees are also eleaned at intervals. Speed of the first or 18-ft. washer is from 150 to 250 r.p.m. and of the second, 200 to 250 r.p.m. For a capaeity of 10 tons per hour eaeh maehine requires 72 gal. of water per min. A unit of two washers with the two trommels requires 25 h.p. The Shuford mine has four washers and the estimated eost of treatment is 22e. per eu.yd., loose measure, with a reeovery of between 50e. and 75e. per eu. yard.

Wooden Grates for Joplin Jigs.[1]—For the large jigs of the Joplin distriet, cast-iron grates have been almost universally used for screens. They were originally designed to replaee eommon screen cloth whieh was eaten away very rapidly by the aeid water. Even the cast-iron grates in some mills are unfit for use after two weeks. A jig grate built entirely of wood has recently been introdueed and is meeting with sueeess. The frame is of yellow pine, the cross-bars of eottonwood, in which are laid V-shaped grate bars of *Bois d'Arc* or hedgewood. These are held in plaee by eover strips of hiekory fastened by countersunk brass serews. The material for the grate bars was ehosen beeause it showed the least expansion in water. In addition to being aeid-proof, these wooden grates wear longer than iron grates, wire eloth or perforated metal, and do not require such frequent eleaning. It is also elaimed that the wooden grates allow flakey particles to pass through easily, thereby increasing capaeity. These wooden grates sell for $20 eaeh, and they have to be renewed about onee a year. A cast-iron grate, renewed every two weeks, eosts $208 per year for eaeh 3x4-ft. eompartment.

Thickener for Cyanide Plants.[2]—A method has lately been developed in the Simmer & Jaek plant and is now in regular operation, which offers many advantages over the usual spitzlutten and spitzkasten. Briefly, it consists in eombining the spitzlutte and dewaterer in one classifier, which reeeives the pulp direct from the tailings launder and delivers its eoarse sand underflow into the tube mill. This classifier is of the eonical type, with peripheral launder for reeeiving the final pulp overflowing to the cyanide plant. In operation, a sufficient quantity of pulp, including return from tube mills, is delivered from the main tailings launder

---

[1] O. Ruhl and F. Sansom. *Eng. and Min. Journ.*, LXXXVIII, 1025.

[2] W. A. Caldecott. *Journ.* South African Assn. of Engrs., Dec., 1908, p. 101; abstr. in *Journ.* Chem., Met. and Min. Soc. of South Africa, IX, 312.

through a by-pass and a vertical inflow pipe, fitted with a horizontal baffle slightly below the surface of the pulp in the center of the classifier. The classifier now in use is 6 ft. diameter at the top and 9 ft. deep, though smaller dimensions can be employed. It is kept filled nearly to the top with sand, and an essential, patented feature consists of an internal, serrated or notched, horizontal diaphragm near the bottom. This insures a steady underflow of thick pulp, containing very little moisture, which can be regulated in amount up to 440 tons of solids per 24 hours. Owing to the thick consistency and slow velocity of the pulp, a large underflow opening (2⅜-in. diameter) is used, which wears but little and can be exactly regulated by an adjustable, horizontal, cut-off gate. To thin down the pulp for satisfactory tube milling, turbid water is withdrawn from the upper portion of the tailings stream and mixed with the underflow, while a further supply from the same source is employed to thin further the tube-mill outflow, prior to amalgamation on shaking tables. By regulating the underflow opening, the tonnage of solids issuing can be altered without changing its percentage of moisture, which is regulated for tube-milling purposes by the independent supply of turbid water. Should the volume of tailings pulp vary, the classifier automatically adjusts itself by the increased or decreased volume of flowing pulp which carries away in the overflow larger or smaller grains, corresponding to its changed velocity. The diaphragm supports a considerable depth of settled sand and prevents change in consistency or a breaking away of the thick underflow, while the large size of the opening precludes choking. In the Simmer & Jack about 440 tons of solids, containing 65 per cent. of over 0.01-in. size and 26 to 28 per cent. of moisture, are delivered per 24 hours. The classifier overflow contains about 10 per cent. of grains over 0.01-in. size, varying with tonnage of ore milled.

Dorr Continuous Slime Thickener.[1]—Settling cones and spitzkasten often give trouble by clogging of the spigot through a sudden rush of material accumulated on the sides. To obviate this trouble, Mr. Dorr's machine has a cylindrical, flat-bottomed tank inside of which is a central, vertical, shaft carrying horizontal arms which, by angles attached to them, gradually move the settled slime toward a discharge spigot at the center of the tank. At the Mogul mill the tanks are 35 ft. diameter and 12 ft. deep; the shaft revolves very slowly. A tank will discharge per day 285 tons of thickened slime containing 39 per cent. of dry solids. These machines have been used in the Liberty Bell mill, Telluride, Colorado.

---

[1] *Mines and Minerals*, XXX, 79.

Treatment of Slimes on Vanners.[1]—A long series of experimental tests on copper slimes at the Detroit mill, Morenci, Arizona, indicates that a better saving can be made by running Frue vanners much steeper than is the common practice. Slopes up to 1 in. per ft. were tried, but the best work was done at a slope of 5 or 6 in. in 12 ft. Incidentally, the fact was brought out that the saving is increased by thickening the pulp feed up to a certain point. Corrugated belts appear to be better than smooth belts. The steeper slope requires faster travel. In general, the finer the material treated, the steeper the slope and the faster the travel.

Results with Richards Classifier.[2]—The following is quoted almost direct. In regard to the work of the classifier, I have hesitated to give out figures until we were a little more sure of our ground. At Great Falls we ran the two coarse spigots, Nos. 6 and 5, upon two Wilfley tables and turned out tailings that were entirely free from free mineral. This was with $2\frac{1}{2}$-mm. material. These two tailings, however, were a little too high in copper, owing to included grains, and they were therefore sent to be recrushed. The two middle products, Nos. 4 and 3, were sent to two Wilfley tables and these turned out extraordinarily clean tailings. I think that they were poorer than any that have been obtained at the mill before; their small copper content was all in the form of included grains. The two fine products, Nos. 1 and 2, were sent to Wilfley tables, but they did no better than any other Wilfley tables fed with whole pulp or mixed feed. In order to clean these and secure high extraction, we separated the slime from the sand tailings of the Wilfley tables. The slime was sent to the slime plant, where it yielded about half its copper on round tables. The sand tailings were screened on an 80-mesh Callow screen, yielding an oversize that was as clean as the third and fourth Wilfley tailings, while the undersize went to a Johnston vanner, yielding tailings as clean as those from the oversize. This performance I have seen reproduced in the Butte Reduction Works and also at El Tiro. In neither place could I find any visible free grains in the products which I have named above as being free from detached mineral.

I also tried the classifier in a Missouri mill, making seven products instead of six by adding the little end spigot as the seventh. The feed included everything below 3-mm. The three coarse products from this classifier were put upon Harz jigs which yielded tailings that were free from free mineral. This result on a Harz jig I have never seen accomplished before by any classifier. I think, therefore, that the classi-

[1] R. Gahl. *Trans.*, A. I. M. E., XL, 517.
[2] R. H. Richards. *Mines and Minerals*, XXIX, 263.

fier is capable of being adapted to any copper or lead concentrating mill, and that when it is so adapted and is run carefully, it will afford cleaner tailings from Wilfley tables and jigs than any other classifier, unless it be the hindered-settling classifier which is being put upon the market in Chicago.

Cylindrical Classifier.[1]—Cone classifiers are objectionable for (1) their excessive depth, which necessitates a choice between the evils of a small spigot, which is liable to clog, and a large spigot which will allow too much fine material to go down with the coarse, and (2) the constantly diminishing area of section toward the bottom, which causes the coarse material to drag down fine material with it, due to its constantly increasing velocity. To obviate these difficulties, a cylindrical tank may be used in which the sands accumulate in the bottom, forming a natural cone with sides of about 45 deg. A convenient size is 3 ft. 6 in. deep and 3 ft. 3 in. diameter.

Nichols Slime-Settling Apparatus.[2]—The Nichols slime-settling apparatus, which removes settled slime as fast as it falls to the bottom of the tank, was referred to last year. A plant which handles 100 tons of fine slimes per day is now using this apparatus in British Columbia. The slime contains 61 per cent. of material below 200 mesh and 31 per cent. between 100 and 200 mesh. The product of the apparatus contains only 27 per cent. moisture. The belt which removes the slimes from the bottom of the tank is 2 ft. wide and travels at the rate of 6 ft. per minute.

Murex Magnetic Process.[3]—Ore is treated with a selective oily substance with which is incorporated magnetite in a fine state. Valuable particles are thereby coated and rendered susceptible to attraction by a magnetic pole inserted in the liquid. Successful tests have been made on Broken Hill tailings.

Installation of Elmore Vacuum Process.[4]—At the following places the Elmore process has been installed on a regular working scale: Dolcoath mine, Cornwall, separating copper sulphide and tin oxide. Ramsley mine, Devonshire, separating copper sulphide from a slatey, micaceous gangue. Dolgelly mine, North Wales, separating chalcopyrite and pyrite from a schistose gangue. Zinc Corporation, Broken Hill, N. S. W., recovery of blende from the tailings of a lead concentration plant. Edmundian copper mine, Africa, on chalcopyrite ore finely disseminated through a felspathic gangue. Garbensberg mine, Sweden, on an ore containing magnetite, chalcopyrite and pyrite in a quartz gangue. Traag

[1] S. Aimetti. *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 20. *Min. Sci.*, LX, 605.
[2] H. G. Nichols. *Min. and Sci. Press*, XCIX, 369.
[3] *Min. Mag.*, I, 142, 310; *Min. and Sci. Press*, XCVIII, 757; *Min. Journ.*, LXXXV, 565; *Eng. and Min. Journ.*, LXXXVIII, 371; *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 28.
[4] A. S. Elmore. *Eng. and Min. Journ.*, LXXXVII, 1775.

mine, Norway, on zinc and lead sulphides associated with a heavy gangue. Hadeland mine, Norway, on zinc blende associated with magnetite and spathic iron. Telemarken mine, Norway, on copper sulphides in a gangue of hornblende, mica schist and hard quartz. Sulitelma mine, Norway, on ore containing chalcopyrite and pyrite in mica schist. Saxberget mine, Sweden, on a mixed zinc-lead-silver ore. In some of the foregoing the Elmore process is used to treat the ore direct, in others it is used on the ore after previous wet concentration.

Elmore Process at Broken Hill.[1]—Continued success is reported for the Elmore process in treating the Broken Hill tailings. Present capacity is 16,000 to 17,000 tons per month, and the earnings on material containing 20 per cent. zinc are about $30,000. per month. The cost of treatment is about $1.35 per ton. The present installation includes 18 grinding pans with 8 sizing screens, 16 units of Elmore apparatus and 20 Wilfley tables for separating the zinc and lead in the Elmore concentrates. De-oiling ovens are used to drive off the small quantity of oil contained in the Elmore concentrates before they are re-treated on the Wilfley tables.

Milling Methods at Rawhide, Nevada.[2]—For recovering the placer gold in this district, lack of water necessitates the use of dry washing. In one type of machine a chain-bucket elevator lifts the gravel to a revolving trommel, the oversize of which goes to the dump while the undersize passes to a form of dry jig having two iron plates 7 ft. long by 1 ft. wide set at an angle to suit the conditions of operation. These plates have D-shaped openings about ½ in. wide and ½ in. deep, through which passes the rising current of air. Across the bottom of the plate a wire screen is attached, while a sheet-iron trough, running the length of the plate, serves to catch the concentrates and also to direct the air current which acts as the separating medium. The air current is produced by a belt-driven fan connected to the gasolene engine which furnishes the power for the whole operation. The plates are given a horizontal motion by suitable mechanism. The machine was operated by a 11-h.p. engine, and is said to have effected a saving of about 90 per cent. of the gold.

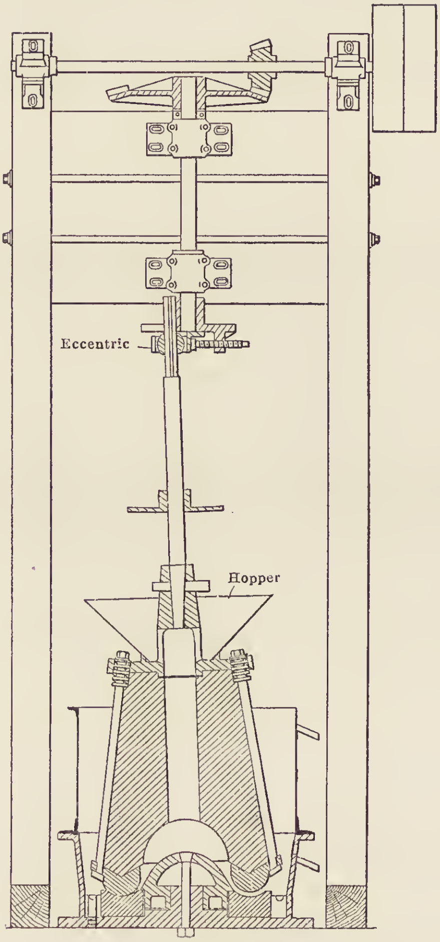
For treating the material from the quartz veins there are two mills, one the Watt and the other the Rawhide quartz mill. The process is amalgamation, followed by concentration. The Watt mill is interesting because it uses, in place of stamps, a new crushing device called the Tadmor mill. This has a gyratory muller operating on the principle of the Kinkead (see Richards' "Ore Dressing," Vol. 1, page 276). A sectional drawing of it is given on the next page.

---

[1] H. C. Hoover. *Eng. and Min. Journ.*, LXXXVIII, 205.
[2] G. E. Wolcott. *Eng. and Min. Journ.*, LXXXVII, 345; *Génie Civ.*, Apr. 3, 1909; *Compt. rend.* de la Soc de l'Ind. Min., Sept., 1909, 547.

In this machine the muller weighs 8000 lb. and is driven with a power consumption of less than 3 h.p., taking a feed of $1\frac{1}{2}$ in. maximum. The mill is said to crush 20 to 25 tons per 24 hours to 40 or 60 mesh, or 12 tons per 24 hours to 120 or 150 mesh.

In the Rawhide quartz mill, three Knight cannon-ball mills treat the product from the Blake breaker. The product of the cannon-ball



TADMOR MILL.

mill goes to a 30-mesh screen, the oversize of which is ground in a fourth cannon-ball mill. The ground product passes over riffles containing mercury and thence between two amalgamated plates lying one above the other. These plates are corrugated crosswise and the plates are so placed that the projections on the upper plate match the depressions in the lower plate. After these amalgamators come five amalgamating plates, 4 ft. wide and 12 ft. long, and finally two Pinder concentrators. The cannon-ball mill has a horizontal, flat disc with three rings at increasing distance from the center, which is the axis of rotation. Each ring carries a number of chilled iron balls which are held in place and under pressure by overhead rings. Ore is fed at the center of the mill and escapes at the periphery. This mill seems to resemble the old American Ball Pulverizer; it has not been in use long enough to determine its merit.

Milling Costs.[1]—A competent mill man should know exactly the saving and the cost of each operation in his mill. The following is the course recommended by the author for the mill man to follow:

1. Get the dry weight of ore milled each day.

2. Arrange the feed-sampling apparatus so that the assay of the feed represents the actual contents of it, rather than an abstract figure on an assay report.

3. Have the spouts carrying the concentrates discharge into trunk launder for each class of product, and let these discharge into their respective bins in such a way as to admit of easy time-sampling.

4. Have hourly time-samples taken of the different classes of concentrates from the above launders, let the total sample of each for 24 hours be weighed and sampled for moisture, and let the assays be made in such a way that the least time will elapse between the sampling and the assay results.

5. Calculate the gross value of the marketable mineral in the feed and in the product each day, at the market rate for that day. The ratio gives the extraction accomplished.

6. Assume a constant as cost for the ore at the mill, say, a certain percentage of the assay value, as a standard for comparison.

7. Figure the actual profit from shipping the different grades of product in No. 4.

8. Find the net daily profit by substracting No. 6 from No. 7, and the daily cost of operating from the remainder.

9. Have each machine in the mill arranged for sampling its feed and products separately by time-sample, if possible.

10. Number each machine and determine the cost of operating it for 24 hours.

Water Required for Concentrating Machinery.[2]—The following approximate data are given in a catalog issued by the General Engi-

---

[1] R. S. Handy. *Min. and Sci. Press*, XCVIII, 156. Abstr. in *Journ.*, Chem., Met. and Min. Soc. of South Africa, IX, 368.
[2] *Mines and Minerals*, XXIX, 380; abstr. in *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 23.

neering Company, of Salt Lake City, for use in making preliminary estimates only: *Stamps and Pulverizers:* For each 800 to 1000-lb. stamp, from 3 to 6 gal. per min. On medium hard ores, with 1000-lb. stamps crushing to 20 mesh, 5 tons per stamp with 3½ to 4 gal. per min. is good work. This produces a pulp of 4 or 5 into 1. Chili and Huntington mills on similar ore will require a total of 5 or 6 tons of water per ton of ore passing the screens. *Jigs:* For each 18x36-in. compartment of Harz jigs treating 1½ to 2½-mm. grains, 2 to 4 gal. per min.; 3½ to 5-mm. grains, 5 to 7 gal.; 7 to 10-mm. grains, 8 to 14 gal.; 15 to 20-mm. grains, 21 to 28 gal. per min. This is in addition to the water in the feed, which can be assumed as not less than equal weights of water and ore. *Revolving Screens* (*Spray Water*): Each 36 to 72-in.screen will require on 1½ to 3½-mm. holes, 15 to 25 gal. per min.; 3½ to 7-mm. holes, 10 to 15 gal.; 7 to 15-mm. holes, 5 to 8 gal. per min. *Callow Traveling Belt Screens* (24-in. Duplex): Pulp containing 3½ to 4 tons water per ton of feed; shaking spray, 6 to 10 gal.; oversize spray, 8 to 12 gal. per min. *Wilfley Tables:* 5 to 10 gal. per min. *Frue Vanners* (6-ft.): 1½ to 3 gal. per min. *Hydraulic Classifiers:* A very variable quantity. Richards gives from 10 to 50 tons water per ton of pulp, or an average of 20 tons for all the mills visited by him.

Water Required for Stamping.[1]—A set of tests at the Camborne School of Mines, gave the following figures of tonnage and water used per 24 hours in a stamp mill with 20-mesh screens:

WATER CONSUMED IN STAMP-MILLING.

Table.	Ore per 24 Hours. Long Tons.	Battery and Classifier Water. Long Tons.	Cleaning Water. Long Tons.
Buss	4.22	50.50	10.37
Frue Vanner (4-ft.)	2.41	10.80	3.45
Acme	2.95	22.85	23.14
Rag Frame	1.14	12.72	12.56

The scheme of treatment included a five-stamp battery and a classifier with three spigots and overflow, the products of which went to the four tables in the order given in the above table.

Carrying Capacity of Launders.[2]—About 3000 experiments were made at the Utah State School of Mines to determine the carrying capacity of a wooden launder under different conditions, and the comparative capacities of launders with glass, linoleum and wooden bottoms. The materials upon which the experiments were made were: (1) 40- to

[1] R. T. Hancock. *Mines and Minerals*, XXIX, 407.
[2] W. C. Browning. *Mines and Minerals*, XXIX, 300. Abstr. in *Journ.*, Chem. Met. and Min. Soc. of South Africa, IX, 440.

60-mesh pyrite; (2) 10 to 30-mesh tailings of almost pure limestone; (3) 4- to 8-mesh gravel which was ordinary rounded pebbles. The method of making a test was to take a weighed quantity of material and feed it by hand into the launder just as fast as the water would take it away. One surprising result was that for the pyrite and tailings the water had a greater carrying capacity in the wood and linoleum launders than in the glass launder. The suggested explanation is that the rough bottoms of the former set up vertical eddies which exert a lifting as well as a sliding action on the grains. In the case of the rounded pebbles the glass launders gave the water a greater carrying capacity because the particles roll rather than slide. Another point brought out was that the carrying capacity, per pound of water, decreased after the velocity of flow in the launder had risen beyond a certain point.

Wolverine Tailing-Disposal Plant.[1]—Steel launders for the tailings of the Lake Superior copper mills must have a slope of $\frac{5}{8}$ in. per ft. to carry away all the water, sand, and slimes. The Mohawk mill, on the shore of the lake, had used all available space and was obliged to elevate the tailings. The management finally decided upon a system whereby the tailings and water were all discharged into a sump together. From this sump, four elevators, with perforated buckets, lifted the sand to a conveyer belt 700 ft. long. The balance of the material in the sump passed out through a launder which sloped 13/16 in. in 10 ft. This scheme increased the available hight of discharge at a point 700 ft. from the mill by 17 ft. above what it had been with a launder sloping $\frac{5}{8}$ in. per foot.

Recently the Wolverine mill has had to solve a similar problem. Instead of the troublesome elevators, a sand separating apparatus was installed which consists of settling boxes delivering thickened pulp through continuous spigots in the bottom. This thickened pulp passes over fixed, inclined screens where the remainder of the water is removed and a product containing only 15 per cent. moisture is delivered to the first conveyer, 600 ft. long. This runs up an incline of 5 deg. during the first part of its length and is horizontal for the remainder. It is followed by a second conveyer, 400 ft. long. The overflow from the settling apparatus passes off through a steel launder 30 in. wide on a slope of $\frac{1}{16}$ in. per ft., or a total drop of 6 ft. 3 in. in 1200 ft. If the whole tailings had been lifted by sand wheel or other device, the launder, sloping $\frac{3}{8}$ in. per ft., would have had a total drop of $37\frac{1}{2}$ ft. The saving in power by the Wolverine method, using 15 h.p., as compared with the centrifugal pump method requiring 100 h.p., is very

[1] C. K. Baldwin. *Eng. and Min. Journ.*, LXXXVIII, 71.

marked, and even more so as compared with a sand wheel of 50 per cent. efficiency, which would require 120 h.p. The Wolverine mill handles 960 tons of rock, and requires 8,500,000 gal. of water per 24 hours.

Disposal of Residue at Kalgoorlie.[1]—Recently some of the mills have introduced sluicing for the disposal of their filter cakes. Dry residues from filter presses are mixed with water in agitators, and are pumped through 6-in. pipes to the tailings dam. The details are shown in the following table:

DISPOSAL OF FILTER CAKES AT KALGOORLIE.

Mine.	Per Cent. Coarser Than 100-Mesh.	Per Cent. Moisture in Cakes.	Water Added Per Ton. Gal.	Per Cent. Residue in Sludge.	Tons Per Shift.	Diameter of Pipe. In.	Total Cost per Ton.
G. Boulder........	6.2	28	110	51.5	180	6	$0.0824
O. Brownhill.......	2.45	24	141	49.5	385	6	0.1196
Kalgoorlie	6.3	20	173	47.2	120	6	0.1510

At the Great Boulder mill a deposit formed in the pipe when the slope was only 1 in 120 for a distance of 3795 ft. At the Oroya Brownhill mill a slope of 1 in 100 for a distance of 3300 ft. gave no trouble, and even at the end of the pipe a stretch of 600 ft. was laid level without causing any trouble.

Examples of Milling Practice.

Ore Dressing in the United States and Mexico.[2]—In this comprehensive survey of the ore dressing conditions the author groups the mills into the following classes:

1. Amalgamation Group.
   - Amalgamation without subsequent treatment.
   - Amalgamation followed by concentration, but not cyaniding.
   - Amalgamation followed by cyaniding or by concentration and cyaniding.
2. Cyaniding Group.
   - Cyaniding without concentration.
   - Cyaniding preceded by concentration.
3. Water Concentration Group.
   - One product.
   - Two or more products.
   - Two or more products with subsequent separation of the more complex products.
4. Miscellaneous Processes.

In the amalgamation group it is not commonly possible to extract a high enough percentage of gold by amalgamation alone, whence cyaniding, or concentration, or both, follow the amalgamation. In some cases it has been found more satisfactory to supplant the concentration and cyaniding of tailings by cyaniding alone. In other cases the concentration is necessary either to recover gold which is not extracted by

[1] Harry Adams, *Proc.* Austral. I. M. E., XIII, 115.
[2] H. A. Guess. *Proc.* Colo. Sci. Soc., IX, 235; *Western Chem. and Met.*, V, 415; *Eng. and Min. Journ.*, LXXXVIII, 864, 966. *Min. Wld.*, XXXI, 782.

cyaniding or to remove harmful minerals which affect the cyanide process. The concentrates may be shipped to the smelter or roasted and chlorinated or finely ground and cyanided. The equipment for mills of this class consists of breaker, stamps, classifiers, Wilfley tables, and vanners. Sometimes canvas plants are used for the slimes. Usually five-stamp mortars are used. In the cyanide group there has been constant improvement in the direction of finer grinding, use of tube mills, application to silver ores, crushing in solution, etc.

The water concentration group perhaps offers the greatest variety of mill schemes. With very few exceptions, separation depends upon specific gravity, but, owing to the varying nature of the ores, one mill will have one arrangement of machines and another mill another arrangement. In the Cœur d'Alene district, Idaho, the ore is coarse and jigging begins at $1\frac{1}{4}$-in. size. At Bingham, Utah, the copper is finely disseminated, and the ore has to be crushed to 1 mm. at least before any free mineral can be saved. The difference is still more marked if we consider that, in the Cœur d'Alene district, hand picking is used to remove clean mineral and waste up to 3-in. size. With the copper ores of Butte and of the Southwest, jigging begins at $\frac{7}{8}$ to $1\frac{1}{4}$ in., but no tailings are thrown away coarser than $1\frac{1}{2}$ to $2\frac{1}{2}$ mm. Lake Superior native copper ore is crushed to 4 or 5 mm. before any concentrates are saved. Tailings are rejected at this same size. In the Joplin district, jigging begins and tailings are discarded at a maximum size of 6 to 12 mm. In the southeastern Missouri lead district the maximum sizes are from 4 to 9 mm.

The usual equipment consists of jaw or gyratory breakers followed by rolls with a limiting trommel. The one exception is the Lake Superior district, where steam stamps are used. Where jigs are used and where concentration begins at 6-mm. size or coarser, the ore is usually divided by trommels into two or more sizes. Trommels are used down to 2 mm., and below that point classifiers are introduced. At Lake Superior, classifiers are used up to 5-mm. size. In Joplin neither classification nor sizing is used. The dividing line between jig and table feed is about 1 mm. Harz jigs are the usual type, but the Hancock jig is used to some extent, for example, in Southeast Missouri, where it seems especially adapted to their problem. The new Richards pulsator jig has been tried with some success at several plants. For regrinding of jig tailings or middlings, rolls are seldom used below $2\frac{1}{2}$-mm. size. Huntington mills, Chili mills, or Bryan mills are preferred. Stamps are not commonly used for regrinding, but single-stamp mortars are doing good service, in some places, as original crushers before concentration. It is quite usual to see coarser screens on the grinding mills than the desired fineness would indicate; for example, a 6-mm. screen will be used where it is desired to crush to 2 mm., the product being sent to a 2-mm. trommel, the oversize of which will go back to the grinding machine. This process increases capacity and saves sliming. For the table work, Callow screens have not supplanted classifiers to any great extent. A large variety of reciprocating tables are used. In vanners the tendency is towards the suspended type and away from the older Frue model. The original article contained the flow sheets, and tabulated statements of results, of important and representative mills in the following localities: Cœur d' Alene, Bingham, Ely, Butte, Cananea, Joplin, Southeast Missouri, Silverton, and Santa Barbara (Chihuahua), which for lack of space cannot be reproduced here even in condensed form. The reader is referred to the original paper.

Ohio Copper Mill, Lark, Utah.[1]—This is the latest of the mills constructed to treat the low-grade disseminated ores of Bingham. The ore differs from the monzonite of the Utah Copper and Boston Consolidated in that it is a hard quartzite. The ore is brought to the mill in five-ton cars, weighed on automatic scales five cars at a time, and dumped into (1).

1. Two 1500-ton coarse-ore bins with flat bottoms, steel frame, lined and floored with double lining of 2-in. planks. The front is lined with ⅜-in. sheet iron. By two gates and two 26-in. belt conveyers to (2).
2. Two grizzlies with 1-in. spaces and sloping 45 deg. Oversize to (3); undersize to (4).
3. Two Blake breakers, 24x16 in., crushing to 1.5 in. These have ring oilers on the moving jaw and on the main bearings. The loose pulley is carried on a separate frame. To (4).
4. Divider, making two equal portions for the two sections of the mill.

ONE SECTION ONLY.

5. Two trommels, 3x6 ft., with 1-in. round holes. Oversizes to (6); undersize to (7).
6. Two Blake breakers, 20x6 in., crushing to 1 in. To (7).
7. Bucket elevator, with 18x9-in. cups spaced at 16-in. centers on a 20-in. belt. To (8).
8. Fine ore bin with sloping bottom holding 100 tons. By two plunger feeders to (9).
9. Two trommels with 7-mm. round holes. Oversize to (10); undersize, water added, to (11).
10. Two pairs of roughing rolls, 36x15 in., Gates, style D. To (7).
11. Four trommels with 3.5-mm. holes. Oversize to (12); undersize to (13).
12. Two pairs of finishing rolls, 36x15 in. By two elevators to (11).
13. Sampler consisting of a sample cutting box attached to a moving belt which passes the cutter through the stream of ore. Lot to (14).
14. Revolving distributer. By trunk launders to (15).
15. Three sets of V-box hydraulic classifiers with six classifiers in each set. First spigot to (16); second to (17); overflow to (18).
16. Eighteen Harz, two-compartment jigs. Concentrates to (29); middlings to (20); tailings to (20).
17. Eighteen Harz jigs like (16); products like (16).
18. Three fixed, inclined 30-mesh screens, sloping 45 deg. Oversize to (19); undersize to (23).
19. Three fixed, inclined 6-mesh screens. Oversize is chips, etc.; undersize to (20).
20. Two 20-in. elevators. To (21).
21. One V-box distributer to (22).
22. Four 7-ft. Monadnock Chili mills, one in reserve, crushing through 26-mesh screen. To (23).
23. Revolving distributer with 27 compartments. By trunk launder to (24).
24. Twenty-seven V-boxes each with two spigots. Each box is 15 ft. 8 in. long, 4 ft. 9 in. deep, 4 ft. 6 in. wide at top and 1 ft. 6 in. wide at bottom. Spigots to (25); overflow to (33).
25. Forty-five Wilfley tables and nine James tables. The latter are put in on trial. Concentrates to (27); middlings to (26); tailings to tailings pond; slime water to (33).
26. Nine Wilfley tables. Concentrates to (27); tailings to (28).
27. Nine Wilfley tables. Concentrates to (29); tailings to (28).
28. Two 4-in. centrifugal pumps in series. To (21).
29. One 20-in. belt elevator. To (30).
30. Two flat-bottomed bins holding 250 tons each and having double lining of 2-in. planks. Discharged through rack and pinion gates with rubber gaskets to railroad cars. The four corners are partitioned off by 16-mesh wire cloth about 12 in. long, which is covered with a double thickness of heavy burlap. Drainings to (29); overflow to (31.)
31. Two bins like (30). Drained concentrates to railroad cars; drainings to (29); overflow to (32).
32. One bin for both sections of the mill. Settlings to railroad cars; overflow used as wash water on (26) and (27).

[1] *Mines and Methods*, I, 157. L. A. Palmer, *Mines and Minerals*, XXIX, 215.

SLIME PLANT.

This is in two sections. Only one section will be described.

33. Automatic revolving distributer. To (34).
34. Three automatic revolving distributers, each with 12 compartments. To (35).
35. Thirty-six pairs of 9-ft. Callow tanks. Spigots to (36); overflow used as wash water on (36).
36. Thirty-six Wilfley tables. Concentrates to (40); middlings to (39); tailings to waste; slime water to (37).
37. Eighteen 9-ft. Callow tanks. Spigots to (38); overflow used as wash water on (38).
38. Six revolving convex slime tables, 20 ft. diameter, with concrete surfaces, making one revolution in 72 sec. Concentrates to (40); middlings to (39); tailings to waste.
39. One 4-in. centrifugal pump. (To (33).
40. One concentrates bucket elevator with belt 20 in. wide. To (41).
41. Two collecting bins and two overflow bins similar to (30) and (31). Concentrates to railroad cars. Overflow used as wash water on (38).

It is expected that an extraction of 80 per cent. will be made, with a concentration of from 18 to 22 tons into one, and at a cost of about 50c. per ton. The labor required in each unit of the main plant will be 1 man on coarse breakers, 1 oiler, 1 lookout and roll man, 1 Chili-mill man, 4 table men and 1 foreman. Both sections of the slime plant will require only three men altogether. In the main plant one man will look after 72 roughing tables or 36 finishing tables. The tailings from the main mill and also from the slime plant are sampled automatically by a teeter box sampler, and then pass to the tailings dam, where they are settled and the water pumped back to the mill. The mill will require 4500 gal. of fresh water per minute. The ore from the lower levels is more finely disseminated and jigs will not be required, in which case the fresh water requirement will be only 3000 gal. per minute.

The following are the special features of this mill. (1) Blake breakers are preferred to gyratory ones. (2) Chili mills are preferred for regrinding. (3) Wilfley tables and slime tables are used for fine sands and slimes. The Utah Copper Company uses vanners and the Boston Consolidated uses Wilfleys and vanners on similar ores. Although the slime tables do not make clean concentrates it is expected that this will be more than balanced by the clean tailings. (4) A double concentration is used with the Wilfley tables, the first step making clean tailings and dirty concentrates, which, by the final treatment, are separated into high-grade concentrates and middlings to be recrushed. This process makes a saving in freight and smelter charges on the concentrates. (5) The machinery is all standardized so that all elevators, rolls, trommels, etc., are of the same size. The top pulleys of all elevators are 42 in. diameter and make 36 r.p.m. The trommels make 19 r.p.m., the rolls 100 r.p.m., and the Chili mills 24 r.p.m.

Electric power is obtained from the Telluride Power Company. The following equipment is for one half of the mill: One 75-h.p. motor for the coarse and fine breakers and first elevator; one 35-h.p. motor for roughing rolls (10); one 50-h.p. motor for finishing rolls and elevators (11); one 40-h.p. motor for jigs; one 150-h.p. motor for four Chili mills; three 20-h.p. motors for tables (25); one 25-h.p. motor for tables (26) and (27) and elevator (29); one 15-h.p. motor for pumps (28); one 20-h.p. motor for 18 tables (36) and distributors (33) and (34);

one 20-h.p. motor for 18 tables (36) and slime tables (38); one 15-h.p. motor for pump (39); one 10-h.p. motor for elevator (40). There are also four 100-h.p. motors to run the four 1000-gal. pumps at the tailings dam for returning water to the mill.

All launders above the first tables are lined with cast-iron bottoms, 1 in. thick. Below that the feed launders are lined with 1-in. board, the concentrates launders are unlined and the middlings and tailings launders are lined with 1-in. cast-iron bottoms. Dry launders slope 45 deg.; launders for wet, coarse ore, 15 deg.; to the jigs and Chili mills, 1.5 in. per ft.; for table products, 1.25 in. per ft.; feed to slime plant, $\frac{1}{8}$ in. per ft.; in slime plant, $\frac{3}{4}$ in. per ft.; main tailings launder, $\frac{5}{16}$ in. per foot.

The automatic distributers used in this mill consist of an annular tank divided radially into as many equal truncated sections as there are portions to be made of the pulp. A central, revolving tank with a spout delivers the pulp in succession to each department. The jig distributer, for example, has an annular tank 18 in. inside diameter, 36 in. outside diameter and 14 in. high.

The main building of the mill is 317 ft. wide and 391 ft. long in the direction of the flow. The slime plant is 342 ft. wide and 115 ft. long in the direction of the flow. The buildings have steel frameworks covered with corrugated iron, and lined with asbestos paper and wire netting. The floor is of concrete and the foundations of all machines are of concrete made high so as to allow men to get under the machines for repairs. The products of the tables and jigs are carried in launders on the concrete floor, which necessitates the placing of wooden grate walks throughout the mill. All machines are provided with loose pulleys or friction clutches. The electric motors are placed above the floor and out of the way. The mill is built on a side hill; the main building has eight terraces and a gallery and the slime plant has two terraces and a gallery. Each terrace has a retaining wall. The mill cost, equipped, about $1,300,000, and the capacity will be between 2400 and 2500 tons per day.

Concentrator for Bingham Lead-Zinc Ores.[1]—The ore from the Jordan and the Galena mines assays 9 to 9.5 per cent. lead, 9 to 9.5 per cent. zinc, 13 per cent. iron and 28 per cent. insoluble. This is concentrated in the United States Company's wet mill, making a lead product for the smelter, containing 7.5 per cent. zinc, and a zinc-iron product which goes to the Huff electrostatic plant, yielding a zinc product low in iron and a pyrite product containing some chalcopyrite and galena, but only 7.5 per cent. zinc.

---

[1] *Mines and Methods* I, 111.

The scheme of the wet mill is as follows:

1. No. 1 bin, holding 450 tons. To (2).
2. Grizzly with 1-in. spaces. Oversize to (3); undersize to (4).
3. Blake breaker, 10x20 in. To (4).
4. One 14-in. bucket elevator. To (5).
5. No. 1 trommel with ¾-in. holes. Oversize to (6); undersize to (7).
6. One pair of roughing rolls, 12x30 in. To (4).
7. Teeter box sampler. Lot to (8).
8. No. 2 bin. By plunger feeder to (9).
9. No. 2 bucket elevator, 14 in. wide. To (10).
10. Two No. 2 trommels with 7.5-mm. holes. Oversize to (11); undersize to (12).
11. One pair of No. 2 rolls, 30x12 in. To (9).
12. One No. 3 trommel with 4-mesh, No. 11 Tyler wire screen. Oversize to (16); undersize to (13).
13. One No. 4 trommel with 6-mesh, No. 14 wire screen. Oversize to (17); undersize to (14).
14. One No. 5 trommel with 8-mesh, No. 16 wire screen. Oversize to (18); undersize to (15).
15. Settling box. Spigot to (19); overflow to fourth cone of (27).
16. Two No. 1, three-compartment, Harz jigs with 3-mesh screens, making 200 strokes of 1½ in. per min. Concentrates from hutches to lead bin; tailings to (21).
17. Two No. 2, three-compartment, Harz jigs with 4-mesh screens, 225 strokes of 1⅛ in. per min. Products like (16).
18. One No. 3, three-compartment, Harz jig with 5-mesh screens, 250 strokes of ⅞ in. per min. Products like (16).
19. Two No. 4, three-compartments, Harz jigs with 6-mesh screens, 300 strokes of ⅝ in. per min. Concentrates from hutches to lead bin; tailings to (20).
20. Settling box. Spigot to (24); overflow to (46).
21. One 30-in. shovel dewatering wheel. To (22).
22. Middlings bin. To (23).
23. One pair of No. 3 rolls, 12x30 in., set close. To (24).
24. No. 3 elevator. To (25).
25. Two No. 6 trommels with 9-mesh, No. 17 wire screen. Oversize to (26); undersize to (27).
26. One pair of No. 4 rolls, 12x30 in. To (24).
27. Five Dillon double cone hydraulic classifiers in series, respectively, 20, 20, 30, 30 and 40 in. diameter. First two spigots to (28); last three spigots to (29); final overflow to (43).
28. One No. 5, three-compartment, Harz jig with 6-mesh screens, 280 strokes of ¾ in. per min. First hutch to lead bin second to zinc bin; third to (45); tailings to (30).
29. Three Overstrom tables. Lead concentrates to bin; middlings to three tables of (45); tailings to (30); slime water to (46).
30. One No. 4 elevator. To (31).
31. One 30-in. shovel dewatering wheel. To (33); overflow to (32).
32. One 7-ft. Callow tank. Spigot to (34); overflow to tailings launder.
33. Tailings bin holding 50 tons. By feeder to (34).
34. One tube-mill, 5 ft. diameter and 14 ft. long. To (35).
35. Two 54-in. Frenier sand pumps in series, lifting 40 ft. To (36).
36. Settling tank, 3x6 ft. Spigot to (39); overflow to (37).
37. One 7-ft. Callow cone. Spigot to (38); overflow to tailings launder.
38. One Sherman slimer. Concentrates to lead bin; tailings to tailings launder.
39. One No. 3, six-spigot, Richards pulsator classifier. First and second spigots to (40); rest of spigots to (41).
40. One Wilfley and one Overstrom table. Lead concentrates to bin; zinc concentrates to bin; middlings to (24); tailings to tailings launder; slime water to (46).
41. Four Wilfley tables. Lead concentrates to bin; zinc concentrates to bin; middlings to (42); tailings to tailings launder.
42. Two Wilfley tables. Lead concentrates to bin; zinc concentrates to bin; middlings to (30); tailings to tailings launder.
43. Seven classifying tanks in series, ranging from 3x6 ft. up to 7x6 ft. Spigots to (44); final overflow to (48).
44. Seven Overstrom tables. Lead concentrates to bin; middlings of first three tables to three tables of (45); middlings of last four tables to one table of (45); slime water to (46); the first three tables also make tailings to tailings launder.
45. Seven Wilfley tables. Lead concentrates to bin; zinc concentrates to bin; tailings to tailings launder; three tables treating stuff from (28) and (29) also make middlings to (30).
46. Slime water tank. By centrifugal pump to (47).
47. Slime water settling tank. Spigot to third tank of (43); overflow to (48).
48. Twelve settling tanks. Spigots to (49); overflow to tailings launder.
49. Six Sherman slimers. Concentrates to lead bin; tailings to tailings launder.

The capacity of the mill is 375 tons per day, running two 8-hour shifts. Power required is 175 h.p. The labor per shift is one foreman, one breaker man, one roll man, one man unloading cars, one jig man, one man tending the tube mill and fine rolls, two table men and one screen man.

The zinc tailings are drained in a stock pile before going to the zinc mill. The tailings are sampled by an automatic teeter box sampler. The products of each machine are also sampled by hand. Average percentages of extraction are 92.5 of the lead, 80 of the zinc, 91 of the gold, 86 of the silver, 80 of the copper and 91 of the iron. The original ore contains 28 per cent. insoluble and 91 per cent. of this is rejected.

The general concentration is 1.8 tons into 1. The ratio for lead is 2.5 into 1, and for zinc 7.5 into 1. The jig product contains 6 per cent. zinc. Of the total concentrates, 70 per cent. comes from the jigs, 3 per cent. from the Sherman slimers, 7 per cent. from the regrinding department and the rest from the tables treating the product from the rolls. The cost of milling is 76c. per ton.

The Sherman slimers save 70 to 75 per cent. of the lead in their feed, but their bill for repairs is heavy. The Overstrom table is preferred as a roughing table on account of its high capacity, but the Wilfley is better for finishing because it makes a better three-mineral separation. The tube-mill feed contains 2 parts water to 1 part solid. The mill makes 28 r.p.m. and with silex liners and Danish pebbles it grinds 125 to 135 tons per day, being run from a 35-h.p. motor. The feed contains 3 per cent. lead, 4 per cent. iron and 9 per cent. zinc. Its work is indicated by the following table:

TUBE-MILL WORK, UNITED STATES MILL.

Size.	Feed. Per Cent.	Discharge. Per Cent.	Size.	Feed. Per Cent.	Discharge. Per Cent.
On 20 mesh	25	....	On 100 mesh	18	17
On 40 mesh	53	9	On 200 mesh	2	20
On 60 mesh	....	15	Through 200 mesh	2	20
On 80 mesh	....	19			

Mill assays for September, 1909, were as follows:

ASSAY OF ORE AND CONCENTRATES, UNITED STATES MILL.

	Gold Per Ton.	Silver. Per Ton.	Copper.	Lead.	Silica.	Iron.	Zinc.
	Oz.	Oz.	%	%	%	%	%
Crude Ore	0.071	4.00	0.56	9.00	27.0	13.5	9.7
Lead Product	0.120	7.50	0.65	22.00	3.0	24.0	8.0
Zinc Product	0.080	3.20	1.30	3.70	5.3	18.8	27.0
General Tailings	0.015	1.50	0.20	1.30	52.5	2.5	3.5

The United States Zinc Plant.[1]—The zinc-iron middlings from the wet mill just described are here treated by the Huff electrostatic separator, which has superseded the Blake-Morscher machine, and has the following advantages: (1) It produces its static electricity from an alternating current by the use of a transformer to step up the voltage, and a specially arranged alternator, instead of by friction machines which are unreliable in dampness. (2) It uses two electrodes with each section of a unit to obtain a concentrated field. One of these is a

[1] *Mines and Methods*, I, 116. F. S. McGregor, *Min. Wld.*, XXXI, 917.

rotating, grounded, steel roller, while the other, the exciting electrode, is a metallic bar or cylindrical rod resting in wooden supports so as to insulate it. The Blake-Morscher machine used only one pole, and that a rotating exciter, and had to use wood to insulate it. (3) Instead of one electrode for rough separation and two other electrodes to clean each of the products from the first, the Huff machine has several pairs of electrodes arranged one above another.

The ore is taken in cars to the mill, raised on a platform elevator, and dumped to (1).

1. Bin. By automatic feeder to (2).
2. Bartlett-Snow revolving cylindrical drier, 2.5 ft. diameter. Coal is the fuel; the hot gases pass around the outside, return through the inside, thence through a centrifugal fan to a dust chamber and thence to the staek. The dryer can bring 20 tons of concentrates, containing 12 per cent. moisture, to bone dryness in 24 hours. Dried products to (3); dust chamber product by chain conveyer at intervals to (3).
3. Main elevator with 4½x8-in. buckets placed at 12-in. centers on rubber belt 8.5 in. wide. By distributer to (4)
4. Three Colorado Iron Works Impact screens in series, each 3 ft. wide and 4 ft. long, sloping 30 deg. and making about 150 bumps per min. No. 1 has 12-mesh; No. 17, wire cloth; No. 2 has 26-mesh, No. 20, wire cloth; No. 3 has 55-mesh; No. 35, wire cloth. Screens are enclosed in a dust-tight room. Oversize of No. 1 screen is low in zinc and goes to pyrite bin. Oversize of No. 2 screen to (5). Oversize of No. 3 screen to (6). Undersize of No. 3 screen to (7).
5. One unit consisting of elevator, feed hopper, Huff roughing separator and two Huff cleaning separators. The two products of the roughing machine go to the two cleaning machines. Clean iron concentrates to pyrite bin for lead smelter; zinc-pyrite middlings returned to elevator; zinc product to zinc smelter; iron-zinc middlings returned to elevator.
6. Two units like (5). Products like (5).
7. Two units like (5). Products like (5).

The finished products go by pipes to V-bottom bins and are drawn off through 2-in. pipes sloping 45 deg. into cars. The mill requires only 30 h.p., and at present its capacity is limited by the drier to 45 tons per 24 hours. The feed from the stock pile contains 4 per cent. moisture. The middlings as they come from the wet mill contain 17 per cent. moisture in the fine sizes and 10 per cent. in the coarse sizes. A new drier is to be installed which is expected to increase the capacity to 55 or 60 tons per day.

The Huff machine has an iron framework with eight electrodes in a vertical line. These are common steel shafting 5 ft. 6 in. long, 1.5 in. diameter and spaced 10.5 in. vertically. They are driven at 200 r.p.m. An adjustable gable divider serves to separate the products from each electrode. The voltage is 20,000, and ¼ h.p. is required for each machine.

Four men are required per shift; one loader, one fireman and two men tending machines. Results are given in the table on the following page.

The cost of treatment is about $2.10 per ton of feed. The capacity of a unit (5) is 12 tons, of (6) is 11 tons and of (7) is 5 tons in 24 hours. The feed going to (7) has 2.7 per cent. on 100-mesh, 36.5 per cent. on 200-mesh and 60.8 per cent. through 200-mesh screen.

Imperial Copper Company's Mill, Arizona.[1]—The principal minerals are garnet and chalcopyrite in limestone and porphyry. The ore averages 3 to 4 per cent. copper and 50 per cent. garnet. The flow sheet of the mill is as follows:

[1] S. F. Shaw. *Min. Wld.*, XXX, 631.

1. Ore from the mine by Porter locomotives. To (2).
2. Ten grizzlies, $1\frac{1}{4}$-in. spacing. Oversize to (3): undersize to (8).
3. 500-ton bin. To (4).
4. Link picking belt. To (5).
5. McCully No. 4 gyratory breaker. To (6).
6. Bucket elevator. To (7).
7. Conveyer belt. To (8).
8. 1200-ton bin. To (9).
9. Two plunger feeders. To (10).
10. Belt conveyer. To (11).
11. Bucket elevator. To (12).
12. 48x72-in. trommel, $1\frac{1}{4}$-in. openings. Oversize to (13); undersize to (14).
13. McCully No. 3 gyratory breaker. To (14).
14. Belt conveyer. To (15).
15. 50-ton mill bin. To (16).
16. Two plunger feeders. To (17).
17. Two 48x96-in. trommels, $\frac{3}{8}$-in. openings. Oversize to (18); undersize to (19).
18. 36x16-in. rolls. To (19).
19. Two trommels, 6-mm. openings. Oversize to (20); undersize to (21).
20. Two 36x16-in. rolls. To (21).
21. Bucket elevator. To (22).
22. Two trommels, 3-mm. openings. Oversize to (23); undersize to (24).
23. Two Duplex Callow 16-mesh screens. Oversize to (25); undersize to (28).
24. Two New Century three-compartment jigs. Concentrates to (44); middlings to (26); tailings to (26).
25. Four New Century three-compartment jigs. Concentrates to (44); middlings to (26) or (36); tailings to (26) or (36).
26. One 6-ft. Evans Waddell mill. Through 16-mesh to (27).
27. Sand Pump. To (28).
28. Two dewatering cones. Underflow to (29); overflow to (38).
29. Two Duplex Callow screens, 40-mesh. Oversize to (30); undersize to (31).
30. Six Card tables. Concentrates to (44); middlings to (36); tailings to (43).
31. Two dewatering cones. Underflow to (32); overflow to (39).
32. Two Duplex Callow 100-mesh screens. Oversize to (34); undersize to (33).
33. Two dewatering cones. Underflow to (34); overflow to (40).
34. Twelve Card tables. Concentrates to (44); middlings to (35); tailings to (43).
35. Four Card tables. Concentrates to (44); tailings to (43).
36. One 5-ft. Huntington mill. Through 40-mesh screen to (37).
37. Sand pump. To (31).
38. Three settling tanks, 12x12 ft. Underflow to (41) and (42); overflow to table wash water.
39. Two settling tanks, 12x14 ft. Underflow to (41) and (42); overflow to table wash water.
40. Three settling tanks, 12x14 ft. Underflow to (41); overflow to vanner wash water.
41. Eight 6-ft. vanners. Concentrates to (44); tailings to (43).
42. Twelve 6-ft. vanners. Concentrates to (44); tailings to (43).
43. Tailings sampler. To (45).
44. Concentrates sampler. To (46).
45. Six 12x14-ft. settling tanks. Traillngs to dump; overflow to (47.)
46. Two 16x8-ft. filter-bottom settling tanks. Concentrates dropped into railroad cars; overflow to (47).
47. Pump tank. To (48).
48. Two 2-stage, 5-in., centrifugal pumps to mill reservoirs.

RESULTS OF HUFF ELECTROSTATIC SEPARATION.

Material.	Gold Per Ton.	Silver Per Ton.	Lead.	Copper.	Zinc.	Iron.	Sulphur.	Silica.	Lime.
	Oz.	Oz.	%	%	%	%	%	%	%
Stock-pile feed (*a*)	0.059	3.19	3.6	1.32	27.0	15.1	27.7	9.9	4.0
Zinc product	0.020	1.80	2.8	0.49	37.9	3.2	22.2	16.2	6.9
Iron product	0.110	4.70	5.3	2.22	5.4	30.3	40.4	4.6	1.6
Recrushed feed (*b*)	0.100	3.30	5.5	1.40	28.0	17.8	33.1	5.8	2.3
Zinc product	0.035	1.90	3.8	0.77	46.8	4.8	27.2	4.8	3.0
Iron product	0.140	4.80	6.6	2.24	10.0(*c*)	26.3	37.4	8.0	1.6

(*a*) The reader should notice the large percentage of silica and lime in the feed, which goes into the zinc product. This is due to the fact that the product was made before the recrushing addltion to the wet mill was in operation. This causes low percentage of zinc in the zinc product.

(*b*) Wet feed from mill after recrushing department was in operation. Owing to large percentage of moisture and insufficient drier capacity, a feed of suitable dryness could not be obtained.

(*c*) This is due mainly to sending damp feed to the electrostatic separators.

Milling at Copper Creek, Arizona.[1]—The Copper Creek Mining Company is installing a 100-ton mill to treat the sulphide copper ores of this district. The flow sheet of this mill is as follows:

[1] R. R. Sibley. *Min. Wld.*, XXX, 477.

1. Grizzly with 1½-in. spaces, 4x10 ft. Oversize to (2); undersize to (3).
2. Blake breaker, 9x15 in., crushing to 1¼ in. To (3).
3. Ore bin. By plunger feeder to (4).
4. Rolls, 16x36 in., ⅜ in. apart. To (5).
5. Bucket elevator. To (6).
6. Trommel, 3 ft. diameter, 6 ft. long, with 6-mm. holes. Oversize to (4); undersize to (7).
7. Shaking screen. 10-mesh, No. 18 wire, 1.34-mm. hole. Oversize to (8); undersize to (10).
8. Richards 4-in. six-compartment pulsator jig. Concentrates to smelter; tailings to (9).
9. Rolls 16x36 in., set $\frac{1}{16}$ in. apart. To (5).
10. Two 8-ft. Callow tanks. Spigots to (11); overflow to waste or used as wash water in mill.
11. Richards 4-in. six-compartment pulsator classifier. Four coarse products to (12); two fine products to (15).
12. Four Wilfley tables. Concentrates to smelter; middlings to (13); tailings by 10x54-in. Frenier sand pump to (14).
13. Duplex Callow screen. Oversize is concentrates; undersize to waste.
14. Rolls, 16x36 in., set $\frac{1}{64}$ in. apart. To (5).
15. Four Card tables. Concentrates to smelter; middlings to (16); tailings to (17).
16. Callow screen. Oversize is concentrates; undersize to waste.
17. Callow screen. Oversize to waste; undersize to (18).
18. Four Card tables. Concentrates to smelter; tailings to waste.

It will be noted that this mill contains special features in the treatment of Wilfley middlings and the fine Wilfley tailings. Investigations that have been made to determine the character of Wilfley table products indicate that the proposed treatment is based on sound principles.

Dry Milling at San Ygnacio, Chihuahua, Mexico.[1]—The vein matter is argentiferous galena and blende in a silicious and calcareous gangue. Some iron pyrites also occurs. The average assay is about 15 oz. silver per ton, 20 per cent. lead, 20 per cent. zinc and 3 per cent. iron. The mill was designed to treat from 30 to 40 tons per day, and cost about $15,000. The ore goes to (1).

1. Dodge breaker, 7x10 in. To (2).
2. Rolls, 14x27 in. To (3).
3. Spiral conveyer. To (4).
4. Drier. By elevator to (5).
5. Impact screen, 12-mesh. Oversize to (6); undersize to (7).
6. Rolls, 14x27 in. To (3).
7. Vibromotor screen with eight sieves, 18- to 200-mesh. Oversize of 18-mesh to (6); other oversizes to (8); undersize of 200-mesh to tailings.
8. Eight ore bins. To (9).
9. Two Sutton, Steele & Steele dry tables. Concentrates to smelter; middlings stored for future magnetic treatment; tailings to waste.

The blowers and tables are run by a 25-h.p. gasolene motor and the rest of the equipment by a 32-h.p. gasolene motor. Each table produces about two tons of concentrates daily, which average 70 per cent. lead and 45 oz. silver per ton.

Concentration at Block 10 *Mine, Broken Hill.*[2]—The ore is variable but averages as follows: Silica, 23.8 per cent.; rhodonite, 12.2; lead, 14.4; zinc, 19.4; iron, 4.6; manganese (MnO), 3.2; alumina, 2.8; carbon dioxide, 3.3; lime, 3.5; sulphur, 12.1; total, 99.3 per cent. Much of the silver is allied with the zinc, and is put away as a by-product for future treatment. The ore wagons at the mine are weighed and dumped to (1).

1. Grizzly, 4x12 ft., with manganese steel bars, 12ft.x4 in.x⅞ in. at top and $\frac{7}{16}$ in. at bottom, spaced ¾ in.; slope 45 deg. Oversize to (2); undersize to (3).
2. Two Austin No. 5 gyratory breakers and one 30x18-in. Blake breaker in reserve. crushing to 1½ in. To (3).
3. Ore bins with capacity equal to 14 hours' mill supply. To (4).
4. Aerial tram made by Pohlig, of Cologne, 2000 ft. long. Speed 5 ft. per sec. Buckets hold 0.5 ton. To (5).
5. Four mill bins holding 17 hours' supply of ore. To (6).
6. Four roller feeders with flanged, cast-iron rollers, 12 in. diameter, 15 in. wide between flanges, making 4 r.p.m. To (7).

[1] O. Peragallo. *Eng. and Min. Journ.*, LXXXVIII, 1263. C. A. Dinsmore, *Min. Wld.*, XXXI, 1209.
[2] V. F. S. Low. *Bull.* 33, A. I. M. E., Sept., 1909, 763; *Min. Wld.*, XXXI, 841, 879.

7. Four shaking screens, 10 ft. 4 in.x1 ft. 8 in., with $\frac{3}{16}$- and $\frac{1}{8}$-in. punched holes, sloping 10 deg. and making 200 shakes of 1.5 in. per minute. Oversize to (8); undersize to (11).
8. Four pairs of Cornish geared rolls, with one roll flanged in each pair. Each roll is 30 in. diameter; the face of the flanged roll is $15\frac{3}{8}$ in. wide and of the unflanged, 15 in. wide. The flanges are 1 in. deep and 1 in. thick at the base. Speed 15 r.p.m. To (9).
9. Four trommels, 62x22 in., with $\frac{1}{2}$-in. punched holes; slope 8 deg., speed 20 r.p.m. Each trommel has four pieces of $1\frac{1}{2}$x$1\frac{1}{2}$x$\frac{1}{4}$-in. angle iron bolted longitudinally to inside of frame, which increases the quality of the products. Oversize to (10); undersize to (11).
10. Four raff wheels 14 ft. 6 in. diameter, 12 in. wide. Speed 15 r.p.m., but 12 r.p.m. would be better. Wheels have great advantages over elevators for moderate lifts. To (9).
11. Four hydraulic classifiers, cone shaped. 35 in. deep and 28 in. diameter at top. Spigots to (12); overflow to (21).
12. Four double May jigs. Each jig has four plunger compartments, 15x30 in., in the middle and four sieve compartments, 12x30 in., on each side. Sieves slope 1 in. toward the tail board. Sieves are, respectively, 8,6, 6 and 5 mesh. Cast-iron shot are used for bed. Plunger has clack valve, 30x6 in., on under side to produce gentle suction. Speed 180 r.p.m. Power required, 1.5 to 2 h.p. Capacity, 5 to 7 tons per jig per hour. Water used, 5500 gal. per hour. First and second hutches, concentrates to (33); third and fourth hutches, middlings to (14); tailings to (13).
13. Two shaking screens. Oversize to (28); undersize of one screen to (29), and of other screen to (30). If material is zinky, a third screen is used, yielding oversize to zinc mill and undersize to (19).
14. Four belt elevators to (15). Overflow of two elevators to (29) and of two elevators to (30).
15. Four No. 3 Krupp ball-mills, 5 ft. 3 in. diameter, 9 ft. 5 in. long, with $\frac{3}{64}$-in. screens, speed 28 to 30 r.p.m., requiring 8 to 10 h.p. to grind 4 or 5 tons per hour. Balls 5 in. diameter wear to $1\frac{1}{2}$ or 2 in., and consume 85 lb. per week. To (16).
16. Four hydraulic classifiers similar to (11). Spigots to (17); overflow to (23).
17. Four double jigs similar to (12) except that sieves are, respectively, 10, 10, 8 and 6-mesh. Speed, 200 r.p.m., requiring 1 to 1.5 h.p. Capacity 4 to 5 tons per hour. Water used, 2200 gal. per hour. First and second hutches, concentrates to (33); third and fourth, middlings to (14); tailings to (18).
18. Four elevators to (19); slime water of two elevators overflow to (29) and of two elevators to (30).
19. Eight grinding pans, 5 ft. diameter, 2 ft. 6 in. deep. Each pan has 18 shoes and dies weighing about 1.75 tons and lasting about 14 weeks. Capacity one ton per hour, using 10 h.p. By four small distributing boxes to (20).
20. Eight Card tables. Concentrates to (33); middlings to (26); tailings to (31).
21. Four hydraulic classifiers similar to (11). Spigots to (22); overflow to (23).
22. Four Wilfley tables. Concentrates to (33); middlings to (23); tailings to (31).
23. Slime thickening box. Spigots by pump through distributing box to (24); overflow to (34).
24. Four spitzkasten, each with four compartments. Length of top, 15 ft. and bottom 10 ft.; upper end 2 ft. 1 in. deep and 2 ft. 8 in. wide; lower end, 4 ft. 8 in. deep, and 7 ft. 1 in. wide. Spigots to (25); overflow to (34).
25. Ten Card tables. Concentrates to (33); middlings of six tables to (26) and of four tables to Card table in (39); tailings to (31).
26. Four spitzkasten like (24). Spigots to (27); overflow to (35).
27. Eight Warren belt vanners with 220 throws of 0.75 in. per min. Lateral slope, 4 deg. Belt travel, 12 ft. per min. Area, 12x4 ft. Concentrates to (33); middlings to (42); tailings to (31).
28. Two coarse tailings bins. Tailings to dump; overflow of one bin to (29) and of other bin to (30).
29. V-shaped settling box. By pump to (23).
30. Settling box. By pump to (38).
31. Bin for vanner and table tailings. Tailings to vanner tailings dump; overflow to (29) and (30).
32. Bin for zinc tailings. Tailings to zinc dump; overflow to (30).
33. Concentrates bins. Concentrates to smeltery; overflow to (43).
34. Settling tanks. Settled slime to (37); overflow to (35).
35. Pump. To (36).
36. Settling tank. Settlings to (34); overflow used as mill water.
37. V-shaped settling box. Thickened slime by pump to (40).
38. One spitzkasten like (24). Spigots to (39); overflow to (35).
39. One Card table, two Wilfley tables and two Warren vanners. Concentrates to (33); middlings to (42); tailings to (31).
40. Two spitzkasten like (24). Spigots to (41); overflow to (35).
41. Two Wilfley tables and three Warren vanners. Concentrates to (33); middlings to dump; tailings to (31).
42. V-shaped settling tanks. Settlings to (45); overflow partly to baffle trough supplying clean water for mill and partly to (43).
43. Pump. To (44).
44. Settling tanks. Spigots to (37); overflow to (35).
45. Four spitzkasten, each with three compartments. Spigots to (46); overflow to (48).
46. Nine Warren vanners and one Wilfley table. Concentrates to bin and thence to smeltery; tailings to (47).
47. Tailings bin. Tailings by elevator to slime dam; overflow to (48).
48. Pump. To (49).
49. Settler. Settlings to (45); overflow to (43).

For water supply, two large service tanks, 20 ft. in diameter and holding 28,000 gal., receive water from mine and mains and also from (36). Another tank, holding 6000 gal. receives water from north slime-dam pump and supplies vanners and tables. Clean water from south slime-dam pump and also from north slime-dam emergency pump is supplied to (48). There are 10 pumps in the mill Two, at the foot of the dumps, are three-throw plunger pumps and the others are centrifugal pumps. The amount of solids in the water varies from 0.5 to 1 lb. per gal. There is a loss of from 105 to 110 gal. of water for every ton treated.

Electricity is used for power as follows: Rolls, raff wheels, shakers, etc., 120; jigs and eight elevators, 40; ball-mills, 40; grinding pans, 80; vanners, tables and elevator, 34; clear water pumps, 104; slime pumps, 30; total, 448 h.p. The Austin breakers and aërial tram take 62 to 68 h.p. The mill treats 3000 tons of ore per week. During the past two years the zinc content of the ore has materially increased and, at present, the concentrates are obtained as follows:

	Weight. Per Cent.	Lead Assay. Per Cent.
Coarse jigs	53.1	63.0
Fine jigs	19.2	53.4
Tables and vanners	23.1	56.7
Regrinding	4.6	60.9
	100.0	Average, 60.6

Samples of the crude ore are taken every half hour and samples of all machines are taken at regular intervals in each shift. Concentrates are sampled after standing a few days for draining before shipment. They average 4.5 per cent. moisture when shipped. The recovery is from 60 to 75 per cent. of the lead and 37 to 55 per cent. of the silver. Experiments on the zinc tailings show that a further recovery of 70 to 80 per cent. of the zinc may be made, together with more of the lead and silver. The cost during one month was as follows: Daily wages, 72.2c.; power, 33.3c.; water and stores, 26.9c.; miscellaneous, 1.2c.; total, $1.34 per ton. Power, water and labor are high.

Concentrates and tailings are removed from their bins in trucks, the latter going to the dumps. Slimes from settlers carry considerable water, which is collected by raising a bank around the edge of the slime dumps, and is pumped back to the mill.

The Austin breakers (2) have proved more satisfactory than jaw breakers, requiring less lubricant, less attention and fewer repairs. They have continuous lubrication of the eccentric, which is above the bevel wheel, and they have an extra bearing for the counter shaft. Trouble with cast-iron eccentrics has been overcome by the use of solid brass. Likewise, a solid brass pinion overcomes trouble from stripping of teeth. There is much wear on the upper bearing of the spindle, and replaceable sheet-steel false bushings $\frac{1}{16}$ to $\frac{1}{8}$ in. thick are used. Both head and concaves are of smooth, manganese steel, ensuring more even and finer crushing, as well as longer life to the head than was the case with corrugated heads. The pinion shaft makes 370 r.p.m. with an average consumption of 25 to 30 h.p., in crushing 25 tons per hour to $1\frac{1}{4}$-in. size.

For the rolls (8), various shells have been tried. Better results are obtained when one shell is of manganese steel and the other of cast-iron or toughened steel. The average life is 14 to 17 weeks. Present practice is to have both shells of toughened steel. A pair of rolls, at 15 r.p.m., requiring 22 to 26 h.p., crushes per week of 144 hours, 900 to 1000 tons of average ore from $1\frac{1}{4}$ to $\frac{1}{8}$-in. size.

In this mill the trommel oversize is returned to the same rolls. In some other mills of the district the series method of passing the oversize along to another set of rolls is used. The advantage claimed for the latter method is less sliming with the disadvantages of (1) increased number of rolls, (2) increased power consumption, (3) extra elevators and bins, (4) increased water, attendance and repairs, (5) work of each roll is dependent on its neighbors. Tests of the two systems at Block 10 mill gave the following results:

COMPARISON OF CRUSHING BY ROLLS.

	Series Reduction. Weight, Per Cent.			Single-Stage Reduction. Weight, Per Cent.		
Slimes and meal in feed	2.89	6.08	3.6	2.93	6.28	3.28
Produced by rolls	12.29	7.89	14.88	14.59	12.97	19.89
Loss—probably slimes	4.80	5.2	4.73	3.34	3.31	4.06
Power consumed in h.p. hours	2.29	2.3	2.14	1.72	1.5	1.52

The May jig has replaced the Hancock in the more modern mills of the district. The jig feed is not closely classified, as is shown in the following table:

CHARACTER OF JIG FEED AT BLOCK 10 MILL.

Size.	Coarse Jig Feed.				Fine Jig Feed.			
	Before Classification.		After Classification.		Before Classification.		After Classification.	
	Weight. Per Cent.	Lead. Per Cent.	Weight. Per Cent.	Lead. Per Cent.	Weight. Per Cent.	Lead. Per Cent.	Weight. Per Cent.	Lead. Per Cent.
Over 20 mesh	43.2	13.6	42.5	12.0	9.8	14.4	13.0	13.0
20 to 40 mesh	21.4	15.6	26.7	13.8	42.0	15.8	44.4	16.0
40 to 60 mesh	8.0	15.4	9.0	17.6	14.7	19.2	15.1	21.6
60 to 80 mesh	8.8	16.7	10.8	19.5	21.4	29.0	18.7	26.0
80 to 100 mesh	....	....	....	....	....	....	....	....
Below 100 mesh	18.6	18.5	11.0	22.5	12.1	30.0	8.8	34.2
	100.0	15.35	100.0	14.94	100.0	20.7	100.0	19.92

Tests have shown that close classification does not yield good results on these ores. Assays of the concentrates from the jigs are as follows, in per cent. of lead:

	Coarse Jigs.	Fine Jigs.
First hutch	67.0	59.0
Second hutch	62.8	51.0
Third hutch	28.7	21.5
Fourth hutch	13.3	12.3
Tailings	3.8	6.2

The character of the ball-mill work is shown by the following sizing tests:

SIZING TESTS ON BALL-MILL WORK.

Size.	Ball-Mill Feed.		Ball-Mill Product.	
	Weight. Per Cent.	Per Cent. Lead.	Weight. Per Cent.	Lead. Per Cent.
Below 20 mesh......	34.7	15.8	9.8	14.4
20 to 40 mesh.......	34.8	19.8	42.0	15.8
40 to 60 mesh.......	9.1	27.2	14.7	19.2
60 to 80 mesh.......	11.3	27.0	21.4	29.0
80 to 100 mesh......	....	....	....	....
Below 100 mesh.....	10.1	34.0	12.1	30.0
	100.0	21.33	100.0	20.7

Sizing tests of the work of the grinding pans working on fine tailings, are shown in the following table:

SIZING TESTS ON GRINDING-PAN WORK.

Size.	Feed.		Product.	
	Weight. Per Cent.	Per Cent. Lead.	Weight. Per Cent.	Per Cent. Lead.
Above 20 mesh......	9.7	5.7	....	....
20 to 40 mesh.......	39.4	5.6	1.6	2.0
40 to 60 mesh.......	13.9	5.4	14.2	3.0
60 to 80 mesh.......	21.5	5.3	51.4	3.2
80 to 100 mesh......	....	....	....	....
Above 100 mesh.....	15.5	13.8	32.8	13.8
	100.0	6.78	100.0	6.63

The Warren vanners are belt tables with a longitudinal shake and a side slope, like the Lührig vanner. The character of the work of the Wilfley tables is shown in the following table:

WILFLEY TABLE WORK.

Product.	Length of Division.	Quantity per Hour. lb.	Weight. Per Cent.	Per Cent. Lead.
Crude material.....	....	805	....	17.3
Concentrates.......	2	130	16.2	67.0
Middlings..........	2	207	25.7	9.4
Tailings 1..........	2	89	11.0	4.0
Tailings 2..........	2	116	14.4	1.5
Tailings 3..........	2	47	5.8	3.2
Tailings 4..........	2	28	3.5	6.3
Middlings 5........	2	188	23.4	14.4

Examples of Coal Washeries.

Coal Washing Plant at Ernest, Penn.[1]—At this washery in Indiana county, Penn., the bituminous coal is separated by gravity screens and

[1] *Mines and Minerals*, XXIX, 251.

trommels into lump, nut and slack. The lump and nut are hand picked, while the slack goes to the washing plant which has a capacity of 750 tons in eight hours, and is arranged as follows:

1. Belt conveyer. To (2).
2. No. 4 E crusher. By elevator and conveyer to (3).
3. Concrete-lined, steel storage bin. By screw conveyers with water to (4)
4. Twenty-four Campbell tables, each 9 ft. long, 2 ft. 7 in. wide, making 62 strokes of 5½ in. per min. Refuse by elevator to bin delivering to railroad cars; coal to sump and then by bucket elevator and horizontal conveyer to larry bin, where it drains before going to coke ovens; water from sump by centrifugal pump to (5).
5. Sludge tank. Settled sludge by drag conveyer and elevator to the coal elevator in (4); surplus water to waste.

Stag Cañon Fuel Company's Washery.[1]—Slack coal from the tipples is brought by belt conveyers to (1).

1. Two 1000-ton storage tanks, 40 ft. diameter, 40 ft. high. By eight feeders to two 28-in. conveying belts and thence to (2).
2. Two 6x12-ft. shaking screens with 1.5-in. round holes. Oversize to (3); undersize to (4).
3. Two sets of toothed rolls, 32 in. diameter, 125 r.p.m. To (4).
4. One 30-in. belt conveyer running over Blake-Denison weighing machine to (5).
5. Dust-proof room. Water added here. By launders to (6).
6. Eight Stewart jigs. Refuse from jig hutches by two No. 5 Lührig elevators to (7); coal to (10).
7. Two trommels, 4x8 ft., with 5/16-in. holes. Oversize to (8); undersize to (9).
8. Stewart jigs. Coal to (10); refuse to (15).
9. Four Lührig jigs. Coal to (10); refuse to (15).
10. Four unwatering trommels. Oversize to (11); undersize to (12).
11. Two 60-in. Stedman disintegrators. Product to (13).
12. Settling tank. Coal removed by perforated bucket elevators to (13).
13. Two conveyer belts in series. To (14).
14. Seven 300-ton steel storage tanks, 20 ft. diameter, 40 ft. high. By larries to coke ovens.
15. Elevators delivering to waste tank and thence by electric trolley cars to waste dump.

The plant has a capacity of 2500 tons in 10 hours. The average loss of fuel in the waste is not over 5 per cent.

New Coal Washery in Michigan.[2]—The washery of the Consolidated Coal Company at Saginaw, Mich., treats 100 tons per hour of coal containing from 3 to 40 per cent. ash, averaging 15 per cent. The washing removes 18 per cent. of the raw coal by weight. The coal is received in (1).

1. Raw-coal elevator-conveyer traveling 100 ft. per min. and having a capacity of 240 tons per hour. To (2).
2. Raw-coal bins holding 150 tons. By gates and revolving feeders to (3).
3. Four Stewart jigs. Coal to (4); refuse to (11).
4. Settling tank. By elevator having capacity of 100 tons per hour to (5).
5. Concentric conical trommel. Inner shell of 5/16-in. steel plate with 1-in. round perforations, 5- and 7-ft. diameters and 14 ft. long. Outer shell of 3/16-in. steel plate with ¼-in. round holes, 7- and 9-ft. diameters, and 13 ft. long Oversize of 1 in. to (6); oversize of ¼ in. to (7); undersize of ¼ in. to (9).
6. Nut-coal bin holding 80 tons.
7. Distributing conveyer. Speed 85 ft. per min. To (8).
8. Fine-coal bin holding 80 tons.
9. Five grading boxes and five Lührig fine-coal jigs. Coal to (10); refuse to (11).
10. Settling tank. Coal by elevator to (7).
11. Refuse elevator and conveyer to waste dump.

The overflow from the settling tank (4) is kept circulating through the jigs and launders by a 12-in. centrifugal pump, lifting 27 ft. at 320 r.p.m. speed.

Washing in the Great Falls Coal Field.[3]—At the Anaconda Copper Company's Belt mine the washery is in two divisions, one for coking coal and the other for non-coking. The non-coking coal on being dumped at the tipple passes down through two 24x30-in. crushers, one reducing to 4 in. and the other to a 2 in. The crushed coal passes into a Dodge

---

[1] J. E. Sheridan. *Trans.* A.I.M.E., XL, 354. *Min. Wld.*, XXXI, 271.
[2] L. Fraser. *Eng. and Min. Journ.*, LXXXVII, 993.
[3] A. T. Shurick. *Eng. and Min. Journ.*, LXXXVII, 587.

conveyer which carries it to storage bins in the washer. This conveyer works on a 10-deg. pitch against the load, is 150 ft. long, and has a capacity of 800 tons in eight hours.

From the storage bin, which holds 700 tons, the coal is elevated and distributed to three Jeffrey-Robinson washers, each having a theoretical capacity of 400 tons and an actual working capacity of about 350 tons. The clean coal from the washers is elevated into the washed coal drainage bins having a capacity of 800 tons, whence it is loaded into railroad cars and shipped for steam coal. The refuse is again elevated and fed by a screw conveyer and a sluice box into two jigs, each having a capacity of 20 tons in eight hours; these two jigs recover about 20 tons of sulphur nodules which are shipped to Great Falls and used at the smelters.

The coking coal on being dumped at the tipple feeds into a conveyer like that of the non-coking coal, but of only 600 tons capacity, whence it is delivered to the coking-coal division of the washer.

The method of washing the coking coal is complex, so that a full outline will not be given. The first floor consists of five tanks which act as temporary repositories for the refuse and different sizes of coal, pending their elevation for re-treatment or final disposal. On the second and third floors are 10 jigs each, all of the Lührig type. The second floor has a crusher and the third floor a crusher and screen, the latter sizing to over $\frac{1}{2}$ in. and under $\frac{3}{8}$ in. The fourth floor has two 6x4-ft. screens and one 8x10-ft.; the latter has a capacity of 400 tons in eight hours and sizes the coal to over $1\frac{1}{2}$ in., 1 in., and $\frac{3}{8}$ in., and under $\frac{3}{8}$ in. The elevating equipment consists of eleven elevators having a range of work from the first to the fourth floor. The building is of brick and steel throughout.

Cardiff Coal Washery.[1]—This plant was designed for an output of 3000 tons in 20 hours. Concrete foundations with steel and brick construction were used in the buildings. The coal comes in cars to (1).

1. Screens with $2\frac{3}{4}$-in. spaces. Oversize hand picked; undersize to (2).
2. Storage bins. By balata belt conveyer to (3) or by elevator to (4).
3. Two raw coal bins. To (5).
4. Large storage bins, used only if plant is shut down. To (3).
5. Two bucket elevators. To (6).
6. Two screens with 10-mm. holes. Oversize to (8); undersize to (7).
7. Two sets of dust extracting apparatus. Dust up to 1- or 2-mm. size is removed by an air blast and is delivered to air-tight chambers, whence it is drawn off and delivered with the final washed and dried product of the plant. The air is used over and over, being in a closed circuit. The residue after removal of dust goes to (8).
8. Classifying screens of the double, balanced, gyrating, Schwidtal type, with 10- and 40-mm. holes. Large nut (40 to 70 mm.) to (9); small nut (10 to 40 mm.) to (11); fine coal (2 to 10 mm.) to (17).
9. Four jigs. Coal to (10); slate to (13); hutch sediment to (20).
10. Draining screens. Coal to bins for market; water and fines to (20).
11. Four jigs. Coal to (12); slate to (13); hutch sediment to (20)
12. Draining and sizing screens, yielding two sizes of coal for market (10 to 20-mm. and 20 to 40-mm.); water and fines to (20).
13. Two elevators. To (14).
14. Nut rewashing jigs. Dirty coal to (15); clean slate by bucket elevators to (16).

---

[1] *Coll. Guard.* XCVII. 217.

15. Disintegrator, preceded by draining screen. Crushed product joins undersize of screen. To (20).
16. Slate bins. By perforated bucket elevators to bins discharging to railway cars.
17. Fourteen jigs for fine coal. Coal to (18); slate to (20).
18. Twenty-four drainage tanks. Drained coal after 10 or 15 hours contains 15 per cent. moisture or less, and goes to market. Drainage water to (19).
19. Spitzkasten. Settlings join fine coal from (18); overflow pumped back to jigs.
20. Collecting pit. By bucket elevator to (21).
21. Trommels with 10-mm. holes. Oversize to (14); undersize to (22).
22. Four fine jigs. Coal to (18); slate to sump and thence to bins discharging to railroad cars.

All washed coal for the market is first dried; later on a briquetting plant is to be erected.

Zollern II Washery, Westphalia.[1]—In this washery the coal is classified at the top before passing through the process. The plant was installed by Schuchtmann & Kremer, of Dortmund. The mine cars are run directly from the cage platform into revolving tipples and are dumped, the coal passing down over an inclined screen which has a back and forward motion. The oversizes go to a moving sheet-iron picking belt, while the through sizes are elevated to the top of the washery, where they are classified and the different sizes are run to different jigs. The sizing is done in four trommels having two divisions with different screen meshes in each trommel. The meshes of the first are 1.5 and 3 in.; second, 0.8 and 1.5 in.; third, 0.4 and 0.8 in.; fourth, 0.15 and 0.4 inch.

The slimes pass into large concrete settling chambers, and the water, after settling, is pumped back and used again. After the fine coal is drained sufficiently dry, which requires about six hours, it is sent to the coke ovens. The dirt is flushed into the mine. Running water carries the different sizes of coal to storage pockets placed above railroad tracks.

The capacity of the washer is 2000 tons in 24 hours; 3300 gal. of water per min. are required. The proportion of water to coal is about 1 to 3. There is approximately 10 per cent. of rock in the coal as it comes from the mine. The cokes contains from 5 to 6 per cent. of ash.

Bibliography of Ore Dressing and Coal Washing in 1909.

For want of space the following contributions to the literature of the subject are referred to by title only:

Sorting, Crushing and Grinding.

Anonymous. "Sorting on the Rand." (*Min. Wld.*, XXXI, 1061.)

Anonymous. "Movable Picking Floor." (*Eng. and Min. Journ.*, LXXXVIII, 472, 884.)

Anonymous. "Little Giant Quartz Mill." (*Min. Wld.*, XXX, 847.)

Anonymous. "Denver Quartz Mill." (*Min. Science*, LIX, 393; *Min. Wld.*, XXXI, 849.)

Anonymous. "Vaughn Automatic Quartz Mill." (*Electrochem. and Met. Ind.*, VII, 289.)

[1] W. S. Hall *Eng. and Min. Journ.* LXXXVII, 1135.

ANONYMOUS. "Osborn Composite Breaker Jaw." (*Colliery Guardian,* XCVII, 926.)

ANONYMOUS. "Sturtevant Ring Roll Mill." (*Eng. and Min. Journ.,* LXXXVII, 855.)

ANONYMOUS. "Progress in Crushing Gold Ores." (*Min. and Sci. Press,* XCVIII, 50.)

ANONYMOUS. "Abbé Ball Mill." (*Electrochem. and Met. Ind.,* VII, 232.)

ANONYMOUS. "Ferraris Ball Mill." (*New Zealand Mines Rec.,* XII, 279.)

ANONYMOUS. "Crushing and Screening Plant at Cornwall Iron Mine, Penn." (*Iron Tr. Rev.,* XLV, 260.)

ANONYMOUS. "Hand Sorting." (*Eng. and Min. Journ.,* LXXXVII, 1097.)

ANONYMOUS. "Tube Mills on the Rand." (*Min. Wld.,* XXX, 939.)

ANONYMOUS. "Champion Breaker." (*Clay Worker,* LI, 589.)

BARKELEW, J. T. "New Cochran Breaker." (*Eng. and Min. Journ.,* LXXXVIII, 264.)

BROWN, F. C. "Tube-Mill Liners." (*Min. Science,* LX, 71.)

CALDER, W. "Crushing and Sorting Underground." (*Min. Wld.,* XXXI, 606.)

CHAPMAN, R. W. "Calculation of Efficiencies of Crushing and Grinding Machines." (*Proc.* Austral. I. M. E., XIII, 154.)

DROTT, M. "Tube-Mill Practice in Australia." (*Min. Science,* LIX, 494.)

HARDINGE, H. W. "Hardinge Conical Tube Mill." (*Min. Science,* LIX, 293; *Electrochem. and Met. Ind.,* VII, 47; *Journ.,* Chem., Met. and Min. Soc. of South Africa, X, 24, 27.)

HUNTOON, L. D. "Sorting Ore by Hand." (*Eng. and Min. Journ.,* LXXXVIII, 964.)

JENE, H. L. "Hand Mortar." (*Eng. and Min. Journ.,* LXXXVII, 788.)

OKE, A. L. "Sample Grinder." (*Eng. and Min. Journ.,* LXXXVII, 990.)

VON BERNEWITZ, W. M. "Dry Crushing Plants at Kalgoorlie." (Min. Journ., LXXXVI, 297; abstracted in *Min. Wld.,* XXXI, 735.)

VON BERNEWITZ, W M. "Dry Crushing Mills." (*Min. Journ.,* Sept. 4, 1909; abstracted in *Journ.,* Chem., Met. and Min. Soc. of South Africa, X, 222.)

WAINWRIGHT, W. E. and MCBRIDE, W. J. "Comparison of Tube-Mill and Grinding Pan." (*Proc.* Austral. I. M. E., XIII, 38.)

WEST, H. E. "Tube-Milling at El Oro." (*Min. Journ.,* LXXXVI, 149; abstracted in *Journ.,* Chem., Met, and Min. Soc. of South Africa, X, 186.)

YATES, A. "Screen Analyses and Grinding Efficiencies." (*Journ.,* Chem., Met. and Min. Soc. of South Africa, IX, 187, X, 99; abstracted in *Min. and Sci. Press,* XCVIII, 624.)

Screening.

ANONYMOUS. "Callow Screen." (*Journ.,* Chem., Met. and Min. Soc. of South Africa, IX, 313.)

ANONYMOUS. "Centrifugal Conical Screen." (*Clay Worker,* LI, 415.)

ANONYMOUS. "Reducing Size of Screen Hole." (*Eng. and Min. Journ.,* LXXXVIII, 329.)

ANONYMOUS. "Concentric Trommel for Screening Stone." (*Colliery Guardian,* XCVII, 470.)

HENDERSON, E. T. "Standard Laboratory Screens." (*Austral. Min. and Eng. Rev.,* Nov., 1908; abstracted in *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 73.)

Steele, E. G. "Sutton, Steele & Steele Vibromotor Ore Sizer." (*Eng. and Min. Journ.*, LXXXVII, 493.)

Wethey, A. H. "Pratt Centrifugal Screen." (*Mines and Minerals*, XXIX, 270.)

Stamp Milling and Amalgamation.

Anonymous. "Amalgam Trap." (*Eng. and Min. Journ.*, LXXXVIII, 1035.)

Anonymous. "Battery Screen Frame." (*Eng. and Min. Journ.*, LXXXVIII, 329.)

Anonymous. "Ideal Gravity Stamp." (*Min. Wld.*, XXX, 699.)

Anonymous. "Luttrell's Process for Saving Fine Gold." (*Min. Science*, LIX, 33; *Austral. Min. Stand.*, May 19, 1909, p. 530; *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 28.)

Anonymous. "McKelvey Amalgamator." (*Min. Science*, LIX, 313.)

Anonymous. "Stamp Heads." (*Eng. and Min. Journ.*, LXXXVIII, 1237.)

Anonymous. "Scraping and Patching Battery Screens." (*Eng. and Min. Journ.*, LXXXVIII, 991.)

Caldecott, W. A. "Silver Coating of Amalgamated Plates." (*Journ.*, Chem., Met. and Min. Soc. of South Africa, Nov., 1908; abstracted in *Min. Wld.*, XXX, 317; *Min. and Sci. Press*, XCVIII, 92.)

Carey, E. E. "Electricity as an Aid to Amalgamation." (*Min. and Sci. Press*, XCVIII, 249.)

Clark, J. E. "Resetting Tappets." (*Min. and Sci. Press*, XCVIII, 748.)

Del Mar, A. "Cushioning Vibration of Cam Shafts." (*Min. and Sci. Press*, XCIX, 877; abstracted in *Journ.* Chem., Met. and Min. Soc. of South Africa, IX, 411.)

Haas, H. and Chalmers, A. "Power in Stamp Milling." (*Min. and Sci. Press*, XCVIII, 216, 314.)

Haynes, J. H. "Economics of Amalgamation." (*West. Chem. and Met.*, Sept., 1908; abstracted in *Journ.*, Chem., Met. and Min. Soc. of South Africa, IX, 438; *Mines and Minerals*, XXIX, 321.)

Haynes, J. H. "Pierce Amalgamator." (*Mines and Minerals*, XXIX, 524.)

Hildebrand, J. H. "Purification of Mercury." (*Journ.* Am. Chem. Soc., Aug., 1909, 934. *Journ.* Chem., Met., and Min. Soc. of S. Africa, X, 224.)

Jane, W. H. "Notes on Stamp Milling." (*Min. Wld.*, XXX, 427.)

Pierce, L. S. "Pierce Amalgamator." (*Min. and Sci. Press*, XCVIII, 216; *Electrochem. and Met. Ind.*, VII, 541.)

Robinson, R. C. "Gravity Stamp Mills." (*Queensland Govt. Min. Journ.*, Oct., 1908.)

Truscott, S. J. and Fuller, J. P. "Reinforced Concrete Foundation for Stamp Batteries at Redjang Lebong, Sumatra." (*Trans.*, I. M. M., XVIII, 25.)

Wet Concentration—General Considerations.

Anonymous. "Selection of Mill Site." (*Eng. and Min. Journ.*, LXXXVIII, 788.)

Allemand, G. "Present Tendency in Ore Dressing." (*Compt. rend.* Soc. de l'Ind. Min., July, 1909, p. 382.)

Christensen, A. O. "Free and Hindered Settling of Mineral Grains." (*Eng. and Min. Journ.*, LXXXVIII, 503.)

Gahl, R. "Calculations in Ore Concentration." (*West. Chem. and Met.*, V, 121; *Journ.*, Chem., Met. and Min. Soc. of South Africa, X, 187; *Electrochem. and Met. Ind.*, VII, 306; *Min. Science*, LIX, 328, 346.)

Hancock, R. T. "Water Required in Milling." (*Mines and Minerals*, XXIX, 315.)

Haultain, H. E. T. "Mill Test for Gold *vs.* Assay." (*Can. Min. Journ.*, XXX, 18.)

Jarvis, R. "Theory of Jigging." (*Trans.* A. I. M. E., 1908, 697; abstracted in *Rev. de Métallurgie*, VI, 599.)

Mackenzie, G. C. "Concentration of Low-Grade Iron Ores." (*Journ.* Can. Min. Inst., XII, 130.)

Rigaud, F. "General Consideration of Present System of Ore Dressing." (*Rev. Univ. des Mines*, Series IV, XXIV, 241.)

Sharwood, W. J. "Measurement of Pulp and Tailings." (*Min. Mag.*, I, 226, 297.)

Taylor, A. "Separation of Metallic Ores by Jigging." (*Trans.* I. M. M., XVIII, 2.)

Van Osdell, E. B. "Specific Gravity of Concentrate." (*Min. and Sci. Press*, XCVIII, 667.)

Concentrating Machines.

Anonymous. "Keeping Feed out of Hancock Jig Tank." (*Eng. and Min. Journ.*, LXXXVIII, 1279.)

Anonymous. "Adjustment of Fine Jigs." (*Min. and Sci. Press*, XCIX, 251.)

Anonymous. "Fastening Screens on Hancock Jigs." (*Eng. and Min. Journ.*, LXXXVIII, 1187.)

Anonymous. "Francis Rapid Concentrator." (*Min. Journ.*, LXXXVI, 361.)

Anonymous. "Hennig Table." (*Can. Min. Journ.*, XXX, 213.)

Anonymous. "History of Wilfley Tables." (*Min. Science*, LIX, 164.)

Anonymous. "Horn Canvas-belt Vanner." (*Min. Science*, LX, 34.)

Anonymous. "Merrill Classifier." (*Eng. and Min. Journ.*, LXXXVII, 808.)

Anonymous. "Tipping Device for Overstrom Tables." (*Eng. and Min. Journ.*, LXXXVIII, 1186.)

Brown, G. W. "Richards Pulsator Classifier at El Tiro Mill." (*Mines and Minerals*, XXIX, 249.)

Copenharve, C. "Churchill Separator." (*Min. Wld.*, XXX, 1069.)

Flood, J. N. "Saving Slimes in Concentration." (*Min. Wld.*, XXX, 1019.)

Gradenwitz, A. "New Concentration Apparatus." (*Eng. and Min. Journ.*, LXXXVI, 227; abstracted in *Rev. de Métallurgie*, VI, 34.)

Nelson, C. N. "Hand Jig in Mexico." (*Eng. and Min. Journ.*, LXXXVII, 910.)

Nichols, H. G. "Treatment of Slime." (*Min. Mag.*, I, 221.)

Owen, T. M. and Stephen, J. F. "Concentration of Fine Lead Ore on Vanners." (*Proc.* Austral. I. M. E., XIII, 143.)

Porter, F. R. "Wash-Water Distributer for Vanners." (*Min. and Sci. Press*, XCIX, 253.)

Richards, R. H. "Investigation of Wilfley Table—II." (*Trans.* A. I. M. E., 1908, 683; abstracted in *Rev. de Métallurgie*, VI, 729.)

Ritter, Etienne. "Short Description of Common Machines Used in Ore Dressing." (*Min. Science*, LX, 84.)

Shepard, F. E. "Richards Pulsator Jig and Classifier." (*Eng. and Min. Journ.*, LXXXVII, 544; *Min. Wld.*, XXX, 51; *New Zealand Mines Rec.*, XII, 451.)

Magnetic Concentration.

ANONYMOUS. "Magnet for Removing Steel from Ore." (*Eng. and Min. Journ.*, LXXXVIII, 1238.)

ANONYMOUS. "Magnetic Separation." (*Min. and Sci. Press*, XCIX, 592.)

ANONYMOUS. "Magnetic Separators." (*Am. Mach.*, XXXII, No. 17.)

FERRARIS, E. "Magnetic Concentration at Monteponi." (*Oest. Zeit. f. B. u. H.*, LVII, 467.)

HANSELL, N. V. "Grondal Magnetic Separation." (*Iron Tr. Rev.*, XLIX, 323; *Min. Wld.*, XXX, 739.)

HANSELL, N. V. "New Grondal Magnetic Concentration Plant in Sweden." (*Eng. and Min. Journ.*, LXXXVII, 909.)

JUDSON, J. N. "History of Electro-Magnetic Separation." (*Eng. and Min. Journ.*, LXXXVIII, 270.)

MCKENZIE, G. C. "Magnetic Concentration of Iron Ores." (*Report* of the Ont. Bureau of Mines, XVII, 226; *Journ.*, Can. Min. Inst., XII, 130; *Iron Tr. Rev.*, XLIV, 858; *Min. Wld.*, XXX,887.)

WOOD, H. E. "Magnetic Concentration of Tungsten Ores." (*Proc.* Colo. Sci. Soc., IX, 154; *Min. Wld.*, XXX, 968.)

Elmore Processes.

ANONYMOUS. "Elmore Patents." (*Eng. and Min. Journ.*, LXXXVIII, 1118.)

BARCLAY, A. "Elmore Process." (*Journ.*, Brit. Federated Soc. of Min. Students, II, 153.)

DESCROIX, M. L. "Elmore Vacuum Process." (*Rev. de Métallurgie*, VI, 1060.)

ELMORE, A. S. "Elmore Vacuum Oil Process on Tin Ore." (*Min. Journ.*, LXXXVI, 267.)

ELMORE, S. "Elmore Vacuum Oil Process at Broken Hill." (*Min. Journ.*, LXXXV, 234; *Glückauf*, XLV, 846; *Eng. and Min. Journ.*, LXXXVII, 219.)

HAEGE, T. "Elmore Vacuum Oil Process at Broken Hill." (*Oest. Zeit. f. B. u. H.*, LVII, 483.)

LINDE, R. "Elmore Vacuum Oil Process at Broken Hill." (*Metallurgie*, VI, 486; *Min. and Sci. Press*, XCVIII, 391.)

STOCKER, J. "Elmore Vacuum Oil Process at Cobar." (*Min. Journ.*, LXXXV, 281; *Eng. and Min. Journ.*, LXXXVII, 177.)

Other Flotations and Special Methods.

ANONYMOUS. "Behrend Flotation Process." (*Can. Min. Journ.*, XXX, 279.)

ANONYMOUS. "Blanc Turbo-Classifier." (*Eng. and Min. Journ.*, LXXXVII, 500.)

ANONYMOUS. "Dry Concentration." (*Mines and Methods*, I, 132.)

ANONYMOUS. "Freygang Levigating and Leaching Apparatus." (*Min. Journ.*, LXXXV, 479.

ANONYMOUS. "Outcome of Flotation Litigation." (*Min. Mag.*, I, 289.)

BROWN, A. SELWYN. "MacQuisten Flotation Process." (*Eng. Mag.*, Sept., 1908; *Can. Min. Journ.*, Oct. 15, 1908; abstracted in *Journ.*, Chem., Met. and Min. Soc. of South Africa, IX, 411.)

SEWELL, F. W. "Flotation Processes." (*Mex. Min. Journ.*, Mar., 1909.)

STECKEL, A. P. "Electromagnetic Flotation Process." (*Electrochem. and Met. Ind.*, VII, 275.)

WALKER, E. "History of Flotation Processes." (*Min. Mag.*, I, 61; abstracted in *West. Chem. and Met.*, V, 469.)

Accessory Apparatus.

ANONYMOUS. "Dewaterer for Jig Tailings." (*Eng. and Min. Journ.*, LXXXVIII, 1235.)

ANONYMOUS. "Launders." (*Min. and Sci. Press,* XCIX, 352.)

ANONYMOUS. "Balata Belts." (*Eng. and Min. Journ.*, LXXXVII, 321.)

ANONYMOUS. "Self-Adjusting Elevator Pulley." (*Eng. and Min. Journ.*. LXXXVIII, 573.)

ANONYMOUS. "Elevator and Conveyer Chain." (*Compt. rend.* Soc. de l'Ind. Min., Feb., 1909, p. 125; *Génie Civ.*, Aug. 15, 1908.)

ANONYMOUS. "Belt Conveyers." (*Eng. Rev.*, London, XX, 226.)

ANONYMOUS. "Shovel Unwaterer." (*Eng. and Min. Journ.*, LXXXVIII, 1083.)

BALDUS, M. "Dust Separators." (*Glückauf,* Dec. 5, 12, 1908; abstracted in *Compt. Rend.*, Soc. de l'Ind. Min., Mar., 1909, 161.)

BECHSTEIN, O. "Driers." (*Sci. American Supplement,* May 22, 1909.)

BROWN, R. G. "Tailings Wheel *vs.* Pump." (*Min. and Sci. Press,* XCVIII, 478.)

CHION, E. "Theory of Shaking Conveyers." (*Bull.* Soc. de l'Ind. Min., Series IV, X, 509.)

GROSVENOR, W. M. "Driers." (*Heat and Vent. Mag.*, May, 1909.)

HERMANNS, H. "Conveyers and Elevators." (*Stahl u. Eisen,* XXIX, 1340.)

HUDSON, W. G. "Conveying Machinery." (*Eng. Mag.*, XXXVII, 609, 775.)

PEELE, R. "Tailings Wheel *vs.* Pump." (*Min. and Sci. Press,* XCVIII, 248.)

SCHMITT, C. O. "Grades for Launders and Pipes." (*Journ.* Chem., Met. and Min. Soc. of South Africa, IX, 242.)

TWELVETREES, W. N. "Conveyers." (*Eng. Rev.*, London, XX, 178.)

ZIMMER, G. F. "Belt Conveyers." (*Cassier's Mag.*, XXXVI, 354.)

Slime Settling.

ANONYMOUS. "Clarifying Water at the Bergwerks Wohlfahrt Mill in Zellerfeld, Germany." (*Preuss. Zeit. f. B., H. u. S.*, LVII, 80.)

ANONYMOUS. "Settling Slimes and Tailings at Stella Mine, New York." (*Eng. and Min. Journ.*, LXXXVIII, 556.)

ANONYMOUS. "Slime-Settling Apparatus." (*Can. Min. Journ.*, Oct. 15, 1908, p. 534; *Journ.*, Chem. Met. and Min. Soc. of South Africa, IX, 411.)

ASHLEY, H. E. "Theory of Slime Settling." (*Min. and Sci. Press,* XCVIII, 831; XCIX, 289; *Journ.* Chem., Met. and Min. Soc. of South Africa, X, 149.)

BABONNEAU, A. "Clarification of Muddy Water by Settling." (*Génie Civ.*, Sept. 4, 11, 1909.)

NICHOLS, H. G. "Slime-Settling Device." (*Eng. and Min. Journ.*, LXXXVII, 837.)

PARMLEE, C. W., and MOORE, H. W. "Settling Analysis for Clays." (*Proc. Am. Ceramic Soc.*, XI, 467.)

PORTER, F. R. "Slime-Settling Tank." (*Min. and Sci. Press,* XCIX, 690.)

Tailings Disposal.

ANONYMOUS. "Disposal of Tailings." (*Eng. and Min. Journ.*, LXXXVIII, 1237.)

ANONYMOUS. "Disposal of Tailings." (*Eng. News,* Oct. 28, 1909.)

MCFARREN, H. W. "Impounding Mill Tailings." (*Min. and Sci. Press,* XCIX, 333.)

Examples of Practice—Amalgamating Mills.

ANONYMOUS. "Mercur Mills, Utah." (*Mines and Methods,* I, 57.)

ANONYMOUS. "Improvements at Simmer & Jack Stamp Mill." (*Eng. and Min. Journ.,* LXXXVIII, 1109.)

ANONYMOUS. "Rand Milling Practice." (*Min. and Sci. Press,* XCVIII, 704.)

BOYD, J. "Palmer Mountain Stamp Mill, Wash." (*Min. Wld.,* XXX, 531.)

BROWN, A. SELWYN. "Milling in Western Australia." (*Eng. Mag.,* XXXVI, 601.)

CHRISTENSEN, C. C. "Large Stamp Mills of the World." (*Min. Wld.,* XXXI, 117.)

COOKE, R. C. H. "Ore Treatment at Giant Mine, Rhodesia." (*Journ.,* Chem., Met. and Min. Soc. of South Africa, Nov., 1908; abstracted in *Eng. and Min. Journ.,* LXXXVII, 543; *Min. Wld.,* XXX, 695; *Min. Journ.,* LXXXV, 366.)

FLEMING, W. L. "Stamp Mills in Rainy River District, Ont." (*Eng. and Min. Journ.,* LXXXVIII, 1064.)

HAMILTON, R. "West Australian Mills." (*Journ.,* West Aust. Chamber of Mines, May, 1909, p. 124; abstracted in *Journ.,* Chem., Met. and Min. Soc. of South Africa, X, 74.)

JOHNSON, H. H. and ROCHE, H. F. "Suggestions for Mill Practice at Deep Level Mines on the Rand." (*Journ.* South African Assn. of Engrs., XIV, 173.)

KIRK, M. P. "Presidio Pan Amalgamation Mill, Shafter, Tex." (*Eng. and Min. Journ.,* LXXXVIII, 818.)

MARTIN, A. H. "Milling Comstock Ores." (*Min. Science,* LIX, 45.)

RADCLIFFE, S. and DREVERMANN, J. "Cassilis Mill, Victoria." (*Proc.* Austral. I. M. E., XIII, 132.)

RICE, C. T. "Milling at El Oro." (*Eng. and Min. Journ.,* LXXXVII, 683.)

SCOBEY, J. "Virginia & Mexico Mill at Jalisco, Mexico." (*Eng. and Min. Journ.,* LXXXVIII, 686.)

SHAW, S. F. "Standard Consolidated Mill." (*Eng. and Min. Journ.,* LXXXVII, 487.)

WALCH, E. "Gold Milling in France." (*Eng. and Min. Journ.,* LXXXVII, 792.)

WOLCOTT, G. E. "Milling at Grass Valley and Nevada City, Cal." (*Eng. and Min. Journ.,* LXXXVII, 439.)

Examples of Practice—Concentrating Mills.

ANONYMOUS. "Boston Consolidated Mill." (*Eng. and Min. Journ.,* LXXXVIII, 828; *Mines and Methods,* I, 45; *Min. Wld.,* XXX, 15.)

ANONYMOUS. "Concentration at the Bluebell Mine." (*Eng. and Min. Journ.,* LXXXVIII, 785.)

ANONYMOUS. "Goldfield Consolidated Mill." (*Min. Science,* LIX, 106.)

ANONYMOUS. "Addition to Goldfield Consolidated Mill." (*Min. and Sci. Press,* XCIV, 825.)

ANONYMOUS. "Milling at Ely, Nev." (*Mines and Methods,* I, 21.)

ANONYMOUS. "New Lead and Zinc Dressing Plant of the Bleischarley Mines." (*Oest. Zeit. f. B. u. H.,* LVII, 42.)

ANONYMOUS. "Santa Barbara Mill, Mexico." (*Mines and Minerals,* XXIX, 369.)

ANONYMOUS. "Utah Copper Mill." (*Mines and Methods,* I, 134.)

ANONYMOUS. "Concentrating Tin Ores at Rooiberg, South Africa." (*Eng. and Min. Journ.,* LXXXVIII, 1109.)

Anonymous. "Dressing Asbestos in Quebec." (*Min. Journ.*, LXXXV, 239; *Journ.* Chem., Met. and Min. Soc. of South Africa, IX, 441; *Min. Science,* LIX, 311.)

Anonymous. "Washing Barite Ore." (*Min. Science*, LIX, 191.)

Ball, L. C. "Irvinebank Tin Mill." (*Queensland Govt. Min. Journ.*, July, 1909; *Min. Mag.*, I, 241.)

Ball, S. N. "Washing Ocher in Georgia." (*Min. Wld.*, XXX, 441.)

Baron, H. J. "Mexican Concentrating Methods and Devices." (*West. Chem. and Met.*, V, 401; *Min. Wld.*, XXXI, 1161.)

Baron, H. J. "Rio Plata Mill, Chihuahua." (*Eng. and Min. Journ.*, LXXXVII, 147.)

Brumell, H. P. H. "Graphite Concentration." (*Can. Min. Journ.*, XXX, 267; *Journ.*, Can. Min. Inst., XII, 205; *Min. Wld.*, XXX, 633; *Rev. de Métallurgie,* VI, 729.)

Burgess, C. I. "Ore Washing at Cripple Creek." (*Mines and Minerals,* XXX, 6.)

Cappa, U. "Concentrating Mixed Ores in Sardinia." (*Oest. Zeit. f. B. u. H.*, LVII, 584, 602.

Carroll, C. M. "Concentration at Silver Mines of Caylloma, Peru." (*Min. Journ.*, LXXXVII, 129.)

Cirkel, F. "Concentration of Chromite." (*Min. Wld.*, XXXI, 969.)

Clère. "Concentration in Algeria and Tunis." (*Eng. and Min. ,Journ.* LXXXVIII, 460.)

Cole, A. A. "Concentrating Cobalt Ores." (*Can. Min. Journ.*, XXX, 323.)

Commans, R. E. "Canadian Concentrating Plants." (*Trans.* I. M. M., XVIII, 180.)

Conran, R. H., "Cornish Tin Dressing." (*Min. Wld.*, XXXI, 549.)

Eickhoff. "Dressing Iron Ore in Dillenburgischen." (*Stahl und Eisen,* XXIX, 97.)

Everding. "Concentrating Tin Ore in Bolivia." (*Glückauf,* XLV, 1325.)

Fay, A. H. "Milan Pyrite Mill." (*Eng. and Min. Journ.*, LXXXVIII, 463.)

Fay, A. H. "Concentrating Mesabi Iron Ore." (*Eng. and Min. Journ.*, LXXXVIII, 770.)

Ferraris, E. "Ore Dressing in Sarlinia." (*Oest. Zeit. f. B. u. H.*, LVII, 403.)

Fohs, F. J. "Cleaning Fluorspar." (*Min. Wld.*, XXXI, 932; *Bull.* 3, Ky. Geol. Surv.)

Haley, D. F. "Milling Auriferous Antimony Ore in Nova Scotia." (*Eng. and Min. Journ.*, LXXXVIII, 723.)

Hanson, H. "Pittsburg-Silver Peak Mill, Nev." (*Mines and Minerals,* XXIX, 569; *Min. and Sci. Press,* XCVIII, 657.)

Herrick, R. L. "Concentration at El Tigre Mill." (*Mines and Minerals,* XXIX, 483.)

Herrick, R. L. "Mill Results on Alice Mine Ore." (*Mines and Minerals,* XXIX, 294.)

Hesse, R. "Ore Dressing at Oss-Mazzurana Mine, Predazzo." (*Metallurgie,* VI, 574.)

Higgins, E. "Concentration at Cobalt." (*Eng. and Min. Journ.*, LXXXVII, 1267.)

Hills, V. G. "Milling Tungsten Ores in Colorado." (*Proc.* Colo. Sci. Soc., IX, 135; *Min. Wld.*, XXX, 1021; *Min. Science,* LIX, 407.)

Hutchin, H. W. "Tin Dressing." (*Trans.* I. M. M., XVIII, 69.)

Marks, E. S. "Malay Tin Concentration." (*Min. and Sci. Press*, XCVIII, 31.)

Martin, A. H. "Custom Mills at Goldfield." (*Min. Science*, LX, 268.)

Martin, A. H. "Desert Mill at Millers, Nev." (*Min. Wld.*, XXX, 771.)

Martin, A. H. "Milling Conditions at Goldfield, Nev." (*Min. Wld.*, XXX, 467.)

Martin, A. H. "Mills at Bullfrog, Nev." (*Min. Wld.*, XXXI, 1157.)

Martin, A. H. "Pittsburg-Silver Peak Mill, Nev." (*Min. Science*, LX, 460.)

Mendenhall, D. "Phosphate Washing in Florida." (*Génie Civ.*, Nov. 21, 1908.)

Osgood, S. W. "Milling in East Tennessee Zinc District." (*Eng. and Min. Journ.*, LXXXVII, 401.)

Palmer, L. A. "Daly West Mill, Utah." (*Min. Wld.*, XXXI, 731.)

Piegza. "New Blende Mill at Neue Helene Mine at Scharley." (*Glückauf*, XLV, 804.)

Poole, W. "Treatment of Broken Hill Ores." (*Queensland Govt. Min. Journ.*, Jan. 15, 1909.)

Pratt, J. H. and Sterrett, D. B. "Monazite Washing in North Carolina." (*Bull.* 30, A. I. M. E., June, 1909, p. 483; *Min. Wld.*, XXXI, 219; *Rev. de Métallurgie*, VI, 521.)

Rider, E. B. "Asbestos Milling in Quebec." (*Can. Min. Inst.*, XII, 618.)

Rowe, J. P. "Washing Montana Sapphires." (*Min. Wld.*, XXXI, 921.)

Rowe, J. P. "Bunker Hill & Sullivan Mill." (*Min. Wld.*, XXX, 318.)

Ruhl, O. "Milling Practice in Southeast Missouri." (*Min. Wld.*, XXX, 1155.)

Stevenson, B. S. "Concentrating Iron Ore at Mineville, N. Y." (*Iron. Tr. Rev.*, XLV, 371.)

Stone, C. A. "Washing Florida Phosphate. (*Eng. and Min. Journ.*, LXXXVII, 490.)

Traphagen, F. W. "New Ore-Dressing Laboratory of Colorado School of Mines." (*West. Chem. and Met.*, V, 361.)

Van Wagenen, H. R. "Milling Tungsten Ores." (*Quart. Colo. School Mines*, III, No. 4, p. 14.)

Wethey, A. H. "Concentration at Butte, Reduction Works." (*Eng. and Min. Journ.*, LXXXVIII, 415.)

Wiard, E. S. "Ore Dressing in the Cœur d'Alene District." (*Eng. and Min. Journ.*, LXXXVIII, 1055, 1104, 1205.)

Williams, G. W. "Tin Dressing in North Queensland." (*Eng. and Min. Journ.*, LXXXVII, 1092.)

Williams, G. W. "Concentration at Broken Hill." (*Eng. and Min. Journ.*, LXXXVII, 939.)

Williams, G. W. "Concentration at Wallaroo & Moonta Mines, Australia." (*Eng. and Min. Journ.*, LXXXVIII, 55.)

Wolcott, G. E. "Mills of Tonopah, Nev." (*Eng. and Min. Journ.*, LXXXVII, 594.)

Worcester, S. A. "Ore Washing at Cripple Creek." (*Min. and Sci. Press*, XCVIII, 291; *Eng. and Min. Journ.*, LXXXVII, 956.)

The Treatment of Coal.

Anonymous. "Coal-Screening and Conveying Plant at Newport, England." (*Colliery Guardian*, XCVII, 72.)

ANONYMOUS. Coal Washery at the Brefeld Mine, Saarbrucken.'' (*Preuss. Zeit. f. B., H. u. S.*, LVII, 80.)

ANONYMOUS. ''New Coal Breaker.'' (*Mines and Minerals*, XXIX, 252.)

ANONYMOUS. ''Scaife Automatic Trough Washer.'' (*Mines and Minerals*, XXIX, 328.)

ANONYMOUS. ''Washing Tests on Coal.'' (*Bull.* 368, U. S. Geol. Survey; abstracted in *Colliery Guardian*, XCVIII, 463.)

ANONYMOUS. ''Removal of Dust in Coal Breaker.' (*Preuss. Zeit. f. B., H. u. S.*, LVII, 80.)

DELAMATER, G. R. ''Coal Washery Plant Control.'' (*Mines and Minerals*, XXX, 55.)

HASEBRINK. ''Washing Plants.'' (*Rev. Univ. des Mines*, Series IV, XXV, 73.)

KECKSTEIN, H. ''Conveying Apparatus for Coal Washing.'' (*Oest. Zeit. f. B. u. H.*, LVII, 607.)

MYERS, C. C. ''Process of Coal Washing.'' (*Min. Wld.*, XXX, 486.)

RODDE. ''Montrambert Coal Washery.'' (*Compt. rend.*, Soc. de l'Ind. Min., March, 1909, p. 134.)

ROGERS, W. O. ''Washing Culm.'' (*Power*, June 15, 1909.)

SAMPLING AND ASSAYING.

By F. F. Colcord.

Discussion of Mechanical Sampling.

Studies in Automatic Sampling.—D. W. Brunton (*Trans.* A. I. M. E., XL, 675) reviews the present practice of ore sampling. Grab-sampling for moisture determinations is still practiced in certain localities, but eventually must be abandoned, as an accurate moisture sample is as important as an accurate sample for the determination of the metals. The well-known difficulties in the Cornish method of coning and quartering are mentioned and illustrated by photographs. The theory of machine sampling is outlined and several types of samplers are described. The design and the flow-sheets of several good automatic sampling mills are given in detail. The use of shaking feeders is apparently on the increase. It is becoming customary to allow the ratio between the weight of the largest particle and the weight of the sample to increase from the start of the operations to the end.

Most convincing evidence that mechanical "time samplers" can be depended upon to yield accurate samples is presented in the form of numerous tables showing the results of sampling and resampling various lots of ore. The data were not obtained from a single mill but from several. Other tables show the results of sampling mixtures of several lots, the component lots having been first sampled individually and the mathematical average calculated. The close agreement between the actual sampling results of the mixtures and the calculated results is the more notworthy since the component lots varied greatly in physical quality and value; they were not mixed before feeding to the mill but were run through in succession.

Screen Analysis in Sampling.—Thomas Kiddie (*Eng. and Min. Journ.*, LXXXVIII, 825) believes that all tests to determine the accuracy of samplers and of sampling methods should include sizing as well as chemical tests. Where the values of the different portions of an ore increase or decrease more or less consistently with the size of the particles in the portions tested, the most accurate sample will be obtained with that machine or sampling method which shows the least variation on sizing analysis. While some studies of sampling machines have been made along these lines, the writer suggests the value of further investigation.

Selective Action of Automatic Samplers.—T. R. Woodbridge (*Eng. and Min. Journ.*, LXXXVII, 269) points out the weakness of the argument as to the selective action of sampling scoops. Admitting that the forward edge of the automatic sampling scoop, as it enters the falling stream, and the rear edge, as it leaves the stream, exert a selective action and divert the coarser ore from the sample, then it must be admitted that the forward edge, just before it leaves the stream, and the rear edge, just as it enters the stream, exert an exactly counterbalancing effect. Another point is that if, through faulty construction or operation, incorrect results are obtained with sampling machines, the causes can be located and correction made, which opportunity does not exist in hand sampling.

J. A. Church (*Eng. and Min. Journ.*, LXXXVII, 516) agrees with Mr. Woodbridge that effects of the selective action of the cutting edges of the scoops, do counterbalance when the question of weight only is considered, but not when values are considered. The idea that the inclusion of, say, one 2-in. piece in the sample, which belonged in the reject, counter-balances the exclusion of a 2-in. piece that did belong in the sample, is not correct. Mr. Church has had in mind the difficulty in making the first cut when the ore is a mixture of sizes from 2 or 3 in. down to dust, while the other contributors have dealt mainly with the subsequent cuts.

Device to Overcome Selective Action.—D. F. Haley (*Eng. and Min. Journ.*, LXXXVII, 862) describes an automatic sampling device which it is claimed does away with the selective action found in other samplers. The sample buckets are mounted on an endless chain and are provided with hinged lips, the object of which is to prevent the ore from entering the buckets until they are well under the discharge spout.

Examples of Sampling Mills.

Goldfield Consolidated.—J. A. Church (*Eng. and Min. Journ.*, LXXXVII, 311) describes the Goldfield Consolidated sampling mill. This treats the entire output of the mine, which comes to it as a sized product; the first cut is consequently made without a preliminary crushing of the ore. Vezin samplers and shaking feed are used. The first sampler cuts the ore stream from back to front instead of from side to side, and the lesser time consumed in the passage of the edge of the scoop across the stream is thought to lessen the opportunity for selective action.

Sampling Mill at Cobalt.—Fine grinding of the ore in a ball mill is the interesting feature of the sampling method to be used at the projected custom sampling mill at Cobalt, Ontario (*Can. Min. Journ.*, Oct. 1, 1909).

All of the ore is to pass through the ball-mill; the pulverized portion is to be screened off, thoroughy mixed and split into four equal parts by automatic riffle samplers. Each quarter will be treated as an independent sample and worked down to the requisite laboratory sample. The metallics from the screening of the ball-mill product will be melted into bullion.

Fire Assaying.

Calculation of Fluxes.—A. A. Steel (*Eng. and Min. Journ.*, LXXXVII, 1243) has worked out a few simple directions for fluxing crucible assays, to take the place of the more intricate calculations by metallurgical methods. An approximate estimate of the mineralogical composition of the sample is made, and the corresponding weight of each mineral present in the amount taken for assay is noted. The amount of flux, silica, borax, soda, litharge, argol or niter, is then readily obtained from the directions. From a pure quartz gangue a bisilicate slag is formed by this system of fluxing, and, when bases are present, a slag lower in silica. Borax is used for its general beneficial effect. The system was devised for student use and in order to simplify calculation, calls for more litharge than is usual.

Influence of Borax.—J. E. Clennell (*Eng. and Min. Journ.*, LXXXVII, 696) has investigated the effect of borax in assay fluxes. The experiments were made with a quartzose ore practically free from base metals except iron, which was mainly present as oxide and in varying amounts. A large excess of borax tended to produce a hard, stony slag, difficult to separate from the lead button and when separated it usually had a film of lead adhering to it. The absence of borax, on the other hand, apparently allowed some of the ore to remain undecomposed, while the separation of the slag from the lead button presented little difficuly. A moderate amount of borax thoroughly decomposed the ore and produced a slag easily detached from the lead button.

Adherence of Lead to Slag.—P. A. Pratt (*Eng. and Min. Journ.*, LXXXVIII, 271) does not believe that the adherence of a skin of lead to the slag, due to an excessive amount of borax in the flux, explains the lack of agreement between duplicate assays. His experience has been that the skin of lead is, on the average, less than 1 per cent of the weight of the lead button, and reassays of the slags did not yield any gold. It was found that where wide discrepancies have persisted, the cause was usually traceable to coarse gold, since the discrepancies still existed with buttons which detached perfectly.

Temperature of Cupellation.—R. H. Bradford (*Journ. Ind. and Eng. Chem.*, I, 181) has determined the temperatures existing during the different stages of cupellation, with the object of determining the minimum temperature of a cupelling button. A Le Chatelier thermo-electric pyrometer was used to determine the temperatures.

The temperature of the heating button was determined by placing the hot junction, protected with a thin coating of fire-clay, well within the molten lead. Small horizontal holes were drilled to points beyond the center at different levels in different cupels, so that by the insertion of the couple the temperature of the cupel itself could be determined. A temperature of 900 deg. C. or above was attained at a point in the cupel directly beneath the button, in all cases in which proper preheating of the cupel had taken place, before cupellation began. The temperature within the cupel and near the molten lead remained at 906 deg. C. or above as long as the button continued to drive. The minimum temperature, at a point ¼ in. above and near the front of the cupel, with a gentle draught through the muffle, is as low as 625 to 650 deg. C. A much safer temperature to maintain, however, is from 650 to 750 deg. The heat of combustion of the oxidizing lead is sufficient to keep the button driving even though the cupel is drawn forward to a cooler position. Feather litharge forms at a temperature below 906 deg. Centigrade.

Bone-Ash vs. "Patent" Cupels.—C. O. Bannister and W. N. Stanley (*Trans.* I. M. M. May, 1909) investigated the thermal properties of cupels, having noticed a marked difference in the behavior of bone-ash cupels and cupels made of other material. The lead seems to be at a higher temperature on a bone-ash cupel than on a patent cupel (patent being used to designate cupels with a magnesite base), even when the two cupels are side by side. Patent cupels require a higher temperature during cupellation and exhibit lower losses than bone-ash cupels. The diffusivity of the two kinds was determined, using a steam jacket for temperatures up to 100 deg. C. and an electro-thermal pyrometer for the temperatures during cupellation. Regnault's apparatus was used for specific heat determinations. Silver-lead buttons cupelled, allowed to solidify, and then to spit, gave the relative rates of cooling of the two kinds of cupel.

The thermal properties of patent and bone-ash cupels are decidedly different. The diffusivity of heat and the specific heat of patent cupels are greater than those of bone-ash cupels, while the actual temperature of the cupelling button is much lower on the patent cupel with similar muffle conditions. The time taken for silver beads to solidify and to spit is longer and the likelihood of spitting is much less with patent cupels.

Absorption by Magnesia Cupels.—L. J. Wilmoth (*Journ.* Chem. Met. and Min. Soc. of South Africa, IX, 347) has found a wide range of gold absorption in using magnesia cupels, even with cupels of the same make. An important reason for this is variation in temperature, and some brands of cupels are more susceptible to this factor than others. A difference as high as 25 per cent. in absorption has been noted between two cupels, one not 2 in. in front of the other.

Assay of Cyanide Precipitate.—F. A. Bird (*Min. and Sci. Press,* Oct. 9, 1909) describes the methods in use in the Salt Lake district for the commercial assay of cyanide precipitate. The principal flux mixture consists of 4 lb. each of sodium carbonate and potassium carbonate; flour, $1\frac{1}{2}$lb.; borax glass, 1lb. Portions of 1/10 A.T. of the precipitate are mixed with 18 grams of flux mixture, 3 grams borax glass, and 50 grams litharge. Three portions are run for silver and six for gold. In the assay of gold precipitate the fusions are run at a moderate temperature, finishing with 30 min. of intense heat; with silver precipitate, the fusion is started at a very low heat and the temperature gradually raised. The portions for silver determination are cupelled first; five times their weight of silver is added to the lead buttons for the gold determination, together with 10 mg. of copper for toughening. The parting is done with two parts of acid to one of water, resulting in flouring the gold. The parted gold is washed twice with ammonia water, and with distilled water.

The assays are corrected for slag and cupel absorption, the slags and cupels from the silver determination being assayed separately from those used in the gold determinations. The fusion charge consists of 50 grams of slag and cupel mixture, 18 grams flux mixture, 10 grams borax glass, 6 grams fluorspar, 30 grams litharge and a light cover of soda.

Another method in use for gold precipitate is similar to the one described up to the point at which the silver-gold bead has been weighed. The beads are dissolved in 50 per cent. aqua regia, the solution diluted and the precipitated silver filtered off, scorified, cupelled and weighed, determining the gold by difference.

Colorimetric Assay for Platinum.—J. C. H. Mingaye (*Records,* Geol. Survey, N. S. Wales, 1909, VIII, Pt. 4, p. 276) describes two colorimetric methods for the determination of platinum especially applicable to low-grade material. The addition of stannous chloride to a dilute solution of platinum containing hydrochloric acid produces an intensely dark red or brownish-red color, the platinic chloride being reduced to platinous chloride without precipitation. Potassium iodide added in slight excess to a solution of platinic chloride produces a deep red color varying to a rose color in very dilute solutions. This last reaction is extremely delicate, one part in 2,000,000 being readily detected.[1]

The usual crucible assay is followed by scorifaction and cupellation with the addition of silver, the cupellation being at a higher temperature than usual. The beads are parted in nitric acid, sp.gr. 1.28, and the silver precipitated with hydrochloric acid from the decanted parting solution. The silver chloride is filtered off and the filtrate evaporated to dryness, taken up with hydrochloric acid and again evaporated to dryness. The residue is again taken up with water containing a few drops of hydrochloric acid, warmed, and allowed to cool and stand for an hour. Any traces of lead or silver are filtered off, the filtrate diluted and either stannous chloride or potassium iodide is added, comparison being made with the standard platinum solution.

Assay of Cyanide Solutions.

Assay for Solution or Slime.—A. Whitby (*Journ.* Chem. Met. and Min. Soc. of South Africa, X, 134) describes a serviceable method for the assay of cyanide solutions and slime residue carrying dissolved gold. Twenty A.T. of solution are placed in a large flask with 15 to 20 c.c. of copper sulphate solution (15 per cent. crystals). If the cyanide strength is much above 2 per cent., more of the copper solution is necessary. After shaking, 7 or 8 c.c. of 1 : 5 sulphuric acid solution is added, and after another shaking, 20 to 30 c.c. of sodium sulphite solution (10 per cent. crystals). The shaking is repeated occasionally during 5 to 10 min., the precipitate allowed to settle, the solution decanted through a large, ribbed filter paper, and finally the precipitate is transferred to the filter. The precipitate is fluxed in a crucible with two parts of borax, one part of litharge, and enough reducing agent to produce a 25-gram button. A 20-min. fusion is usually sufficient. Solutions carrying little or no cyanides or ferro-cyanide are made faintly alkaline, and enough potassium cyanide to bring the strength to 0.1 per cent., and 5 to 6 drops of potassium ferro-cyanide (10-per cent.) are added. Auric chloride solutions are not amenable to this method.

Slimes residue if treated as above with such quantities of reagents as are necessary for the ratio of solution to dry slime can be dried without loss and full assay value recovered.

H. A. White (*op. cit.* 136) varies the above procedure by using a saturated solution of cuprous chloride in hydrochloric acid and a 5-per cent. solution of potassium ferro-cyanide. A drop of silver nitrate, for inquarting, a few drops of ferro-cyanide, followed by enough of the cuprous chloride solution to bleach the first-formed precipitate of

[1] F. Field. "Select Methods of Chemical Analysis" (W. Crookes) p. 444.

cupric ferro-cyanide are added in turn. A further portion of ferrocyanide is then added to flocculate the brownish precipitate until it settles readily.

Assay of Acid Washes.—L. J. Wilmoth (*op. cit.* p. 136) has compared the efficiency of several methods of assaying acid washes resulting from the cyanide "clean up" by the use of bisulphate. Method No. 1 consisted of acidifying with sulphuric acid and adding copper sulphate and zinc fume. In method No. 2 the solution was acidified with hydrochloric acid and sodium sulphide and a solution of lead acetate were then added. Method No. 3 was a modification of No. 1, the copper being dissolved out of the precipitate on the filter paper with nitric acid. Method No. 4 was evaporation with litharge and No. 5 was the "Chiddey" method. The investigation seemed to indicate that the "Chiddey" method was the most satisfactory.

Del Mar's Method of Precipitation.—A. Del Mar (*Eng. and Min. Journ.*, LXXXVIII, 1180) adds aluminum sulphide to cyanide solutions and acidifies with sulphuric acid, to precipitate the silver and gold in assaying such solutions.

Precipitation by Aluminum.—W. H. Seamon (*West. Chem. and Met.*, Aug., 1909) uses aluminum in place of zinc for the precipitation of the gold and silver in assaying cyanide solutions. One A.T. or more of solution is taken for assay, a V-shaped piece of aluminum placed in the solution and sulphuric acid added to acid reaction. After prolonged boiling, which is necessary only when silver is present, the aluminum is removed and washed free of the precipitate. The residue is filtered off, dried, scorified and cupelled, as usual. The precipitaion with aluminum has been found to be complete.

Assay of Bullions.

Gold and Silver in Copper Bullion.—F. F. Hunt (*Eng. and Min. Journ.*, LXXXVII, 564) describes his sulphuric acid method for the determination of gold in copper bullion. A mixture of 80 c.c. concentrated sulphuric acid and 25 c.c. of a cupric sulphate solution (160 grams per 1000 c.c.) is heated in a low, wide, No. 5 beaker to such a temperature that action begins immediately upon the addition of the borings. One A.T. of borings is added to the mixture and the whole heated for 1 to 1½ hours, or until all action has ceased. When cool, 400 c.c. water is stirred in, the solution brought to a boil and filtered. The residue is scorified and cupelled in the usual manner. Silver may be determined in the filtrate by adding enough potassium permanganate to produce a permanent color, then one drop of saturated salt solution and 10 c.c.

of a 10-per cent. lead acetate solution, stirring well and allowing the precipitate to settle overnight.

F. B. Flinn (*Eng. and Min. Journ.*, LXXXVII, 569) uses the sulphuric acid method for the determination of gold in copper bullion. A solution of mercuric nitrate or sulphate equivalent to 100 mg. of mercury is added directly to the borings, agitating them a little, and then 80 c.c. of concentrated sulphuric acid is added. After boiling 45 min. the solution is cooled, 400 c.c. of hot water added, stirring meanwhile to dissolve all of the crystals, and then boiled again for 15 min. The solution is allowed to settle and is then filtered through a triple filter. The author believes that the low results obtained with the nitric acid method are due to the inability of the filter to retain all of the gold in its finely divided condition, caused by the violent action of the nitric acid. He also has not had any difficulty in precipitating the silver in the filtrate with salt solution, and does not see the necessity of adding permanganate, as described by Mr. Hunt.

Assay of Silver Bullion.—W. M. Peschel and R. Kann (*Min. Sci.*, July 15, 1909) described the methods used in Eastern refineries for the assay of silver bullion and fine silver. The sampling of silver bullion is usually done by sawing or drilling, and the resulting sawings or drillings are ground in a mill. Fine silver is usually sampled by granulating a small ladleful of the molten silver. The Gay-Lussac method for the determination of silver is not much used except by the mints. The sulpho-cyanate method and a modification of it are in most common use. The modification of the sulpho-cyanate method lies in the use of hydrochloric acid for the precipitation of the major portion of the silver.

Impure silver bullions are assayed by the fire method, either straight cupellation or cupellation preceded by scorifaction. In both the wet and fire methods, "proofs" are run.

Preparation of Proof Bullion.—The preparation of proof gold and silver is described in the *Pacific Miner,* Oct., 1909. Hydrobromic acid is employed as the silver precipitant in preparing the proof gold. Four precipitations of the gold are made, two with sulphur dioxide and two with oxalic acid. Proof silver is prepared electrolytically, using an electrolyte of silver nitrate containing one per cent. of free nitric acid. The anode is made from silver 999 fine and is wrapped in filter paper and muslin cloth to retain the impurities. The cathode is a plate of pure silver. Another method for making proof silver is the well-known one of dissolving fine silver in nitric acid, filtering off the gold, and precipitating the silver with hydrochloric acid.

Bibliography of Sampling and Assaying in 1909.

The following references are in addition to those abstracted on preceding pages:

ANONYMOUS. ''Fire Assay for Lead.'' (*Min. Sci.*, Mar. 10, 1909.)

ANONYMOUS. ''Assays of Copper Bullion, Ores, Slags, etc.'' (*Boletin* de la Soc. Nacional de Minera, XXI, May, 1909.)

BENNETTS, B. H. ''Sampling of Low-Grade Ores.'' (*Eng. and Min. Journ.*, LXXXVIII, 2731.)

BOERICKE, W. F. ''Modification of the Chiddey Method for Cyanide Solutions.'' (*Eng. and Min. Journ.*, LXXXVIII, 525.)

DEWEY, FREDERIC P. ''Variations in Assays by the U. S Mints.'' (*Trans.* A. I. M. E., 1909.)

DUPREY, W. S. ''Assay of Cyanide Solutions.'' (*Mex. Min. Journ.*, July, 1909.)

HOWSON, J. W. ''Limits of Error in Assay Work.'' (*Min. and Sci. Press*, Sept. 4, 1909.)

HUNTOON, L. D. ''Preparing Ore Samples for Student Work.'' (*Trans.* A. I. M. E., 1909, 1019.)

JENE, H. L. ''Mortar for Laboratory Crushing.'' (*Eng. and Min. Journ.*. LXXXVII, p. 788.)

LEDOUX, A. R. ''Sampling Cobalt Ores.'' (*Can. Min. Journ.*, July 1, 1909.)

STANLEY, G. H. ''Platinum Parting Apparatus.'' (*Journ.*, Chem., Met. and Min. Soc. of South Africa, Feb., 1909.)

VAN ZWALUWENBURG, A. ''Comments on Automatic Samplers.'' (*Eng. and Min Journ.*. LXXXVII, 420.)

AUSTRALASIA.

In the following tables the production of minerals and metals in each of the Australian States and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the States are not separately treated, the combined statistics of the Commonwealth now being officially reported.

MINERAL PRODUCTION OF NEW SOUTH WALES. (*a*)

(In metric tons or dollars; £1=$5.) (*b*)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1896	1,394	134	42	3,914	3,972,069	26,774	....	15
1897	736	172	3	3,433	4,453,729	65,229	....	169
1898	2,988	83	29	2,145	4,781,551	83,538	119	181
1899	935	332	16	5,327	4,670,580	98,074	193	445
1900	1,946	252	11	3,338	5,595,879	128,238	145	867
1901	3,196	90	21	2,523	6,063,921	130,944	112	655
1902	3,702	58	10	508	6,037,083	128,902	35	3,190
1903	2,524	13	23	1,982	6,456,523	163,161	155	1,750
1904	376	111	41	404	6,116,126	173,742	6	2,470
1905	2,745	394	56	53	6,738,252	165,568	*Nil.*	487
1906	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(*g*)
1907	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(*g*)
1908	1,099	119	9	*Nil.*	9,293,377	288.413	*Nil.*	(*g*)
1909	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(*g*)

Year.	Copper Matte, Ingot and Regulus.	Diamonds. *Karats.*	Gold. (*b*)	Lead, Argentiferous. (*f*)		Lead. Pig. (*f*)	Molybdenite.	Opal.
				Ore.	Metal. (*e*)			
1896	4,464	8,000	$5,222.971	271,641	19,886	24	..	$225,000
1897	6,458	9,189	5,373,596	275,249	18,395	32	..	375,000
1898	5,577	16,493	5,847,680	394,676	10,270	1,745	..	400,000
1899	5,574	25,874	7,899,075	431,126	20,614	(*d*)4,896	..	675,000
1900	6,243	9,828	5,211,097	426,480	19,400	(*d*)6,807	..	400,000
1901	6,184	9,322	3,587,040	406,560	17,191	(*d*)3,394	..	600,000
1902	5,560	11,995	3,333,064	371,496	15,660	(*d*)4,685	16	700,000
1903	8,094	12,239	5,255,421	335,870	18,779	(*d*)3,561	31	500,000
1904	6,654	14,296	5,576,966	373,362	30,212	(*d*)5,977	26	285,000
1905	7,899	6,354	5,669,099	420,266	28,244	214	20	295,000
1906	9,911	2,827	5,249,762	377,890	22,573	60	34	282,500
1907	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395.000
1908	9,215	2,205	4.646,451	364,488	(*h*)	15,174	9	209.000
1909	7,078	5,474	4,231,211	273,628	(*h*)	15,724	29	309,000

Year.	Platinum. Kg.	Shale Oil.	Silver—Kg. (f)	Tin. Ore.	Tin. Block.	Tungsten Ore.	Zinc. (c) (f)
1896	75.8	32,348	6,307	98	1,147	....	....
1897	61.2	34,635	4,666	14	799	....	29,303
1898	38.9	30,164	16,580	1	639	....	39,564
1899	19.8	37,307	21,525	5	749	....	50,677
1900	15.6	23,229	24,080	15	1,087	....	20,594
1901	12.1	55,650	13,950	11	659	....	642
1902	11.6	63,886	33,195	23	502	....	1,281
1903	16.5	35,332	34,195	556	949	9	21,086
1904	16.6	38,477	34,880	586	1,084	106	58,523
1905	12.4	38,838	12,987	726	817	228	105,189
1906	6.4	32,965	8,865	(h)	1,698	245	105,325
1907	8.6	48,088	63,573	(h)	1,945	409	241,015
1908	4.2	47,044	77,490	(h)	1,822	247	281,147
1909	13.7	49,500	53,430	(h)	1,974	129	379,907

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported £1=$4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND. (a)
(In metric tons or dollars; £1=$5.)

Year.	Bismuth Ore.	Coal.	Copper.	Gold (b)	Lead.	Manganese Ore.
1895	60	328,237	441	$13,056,414	369	361
1896	....	377,332	589	13,235,842	628	305
1897	1	364,142	293	16,699,477	391	403
1898	8	414,461	63	19,016,763	252	68
1899	2	501,913	164	19,571,662	57	747
1900	8	505,252	386	20,002,290	207	77
1901	20	548,104	3,110	12,367,276	570	221
1902	1	509,579	3,845	13,238,500	271	4,674
1903	11	515,950	4,995	13,818,653	3,856	1,341
1904	20	520,232	4,440	13,210,869	2,079	843
1905	15	537,795	7,337	12,249,157	2,464	1,541
1906	7	610,480	10,238	11,257,316	2,854	1,131
1907	6	694,204	12,959	9,641,789	5,240	1,134
1908	22	707,473	14,932	9,613,051	7,207	1,403
1909	11	768,720	14,727	9,416,576	5,323	613

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1895	....	$163,750	6,999	2,148	25
1896	....	116,500	8,687	1,579	3
1897	....	51,250	7,280	1,222	13
1898	....	33,225	3,235	1,041	79
1899	....	45,000	4,521	1,322	263
1900	....	37,500	3,514	1,133	193
1901	....	37,000	17,777	1,638	73
1902	(c) 42	35,000	21,813	2,118	56
1903	(c) 24	36,500	19,972	3,768	200
1904	(c) 22	17,750	20,370	3,986	1,564
1905	64	15,000	18,716	4,008	1,434
1906	108	15,000	24,357	4,900	785
1907	68	15,000	28,662	5,222	627
1908	89	12,500	36,200	4,903	426
1909	94	10,000	31,140	3,379	617

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold values are reported £1=$4.866. (c) Includes bismuth and tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA. (a)
(In metric tons or dollars; £1=$5.) (b)

Year.	Copper. Ore.	Copper. Metal.	Gold. (b)	Iron Ore.	Lead.	Limestone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
1896	354	4,176	$69,827	....	45	....	....	....	$3,775
1897	554	4,267	189,871	....	74	....	....	....	14,340
1898	545	4,847	51,949	....	321	....	....	....	2,800
1899	2,938	5,584	75,822	....	370	....	....	....	6,785
1900	2,405	4,964	70,528	....	389	....	....	....	2,055
1901	1,896	6,844	80,839	....	69	....	....	....	11,095
1902	2,620	6,956	121,056	....	2,210	....	....	....	3,710
1903	7,182	6,594	139,411	86,291	732	....	1,016	40,640	500
1904	3,100	6,378	369,938	47,434	....	44,135	3,048	40,640	990
1905	2,604	6,653	223,121	85,835	53	45,210	5,080	33,020	6,305
1906	535	8,339	131,382	76,430	51	32,451	5,944	55,880	11,045
1907	....	8,058	99,948	85,954	....	31,598	8,128	76,200	12,500
1908	....	5,718	59,852	89,412	....	29,973	11,177	76,204	22,500
1909	1,250	5,788	146,982	16,379	142	13,986	3,833	52,232	19,365

(a) From *Review of Mining Operations* by Hon. A. H. Peake, Adelaide, 1910. (b) Where gold is reported, £1=$4.866

MINERAL PRODUCTION OF TASMANIA. (a)
(In metric tons or dollars; £1=$5.) (b)

Year.	Coal.	Copper Ore.	Blister Copper	Gold. (b)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1896	44,286	(d)	52	$1,156,035	203	21,150	3,867
1897	43,210	(d)	(d)	1,407,447	999	17,806	3,282
1898	49,902	(c)	(d)	1,369,706	1,296	196,707	2,882
1899	43,803	(d)	(d)	1,593,834	6,726	424,552	3,333
1900	51,549	4,221	9,343	1,538,727	5,141	453,519	2,693
1901	49,963	11,401	10,141	1,436,326	1,422	804,463	2,516
1902	49,647	8,630	7,869	1,467,454	2,424	47,226	1,989
1903	49,856	3,891	6,791	1,237,925	6,076	43,103	2,414
1904	62,090	(d)	8,826	1,362,587	6,950	51,959	2,104
1905	52,825	(d)	9,919	1,520,101	6,401	76,424	3,953
1906	53,742	2,270	8,847	1,240,650	2,642	88,513	4,545
1907	59,833	1,261	8,378	1,350,836	3,048	91,216	4,412
1908	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909	67,224	1,613	8,472	925,518	(d)	81,668	4,583

(a) From *Statistics of the Colony of Tasmania*. (b) Where value of gold is reported, £1=$4.866. (c) Included with lead-silver ore. (d) Not reported.

MINERAL PRODUCTION OF NEW ZEALAND. (a) (b)
(In metric tons or dollars.) (c)

Year.	Antimony Ore.	Chrome Ore.	Coal.	Coke.	Copper Ore.	Gold. (c)	Kauri-gum.	Manganese Ore.	Silver. *Kg.*
1896	21	....	805,537	107	....	$5,067,589	7,240	66	2,933.3
1897	10	....	854,164	......	....	4,769,673	6,748	183	5,719.8
1898	....	....	921,546	9	2	5,258,642	10,063	220	9,140.0
1899	....	....	990,838	18	....	7,363,100	11,294	137	10,865.6
1900	3	28	1,111,860	......	12	7,005,103	10,322	166	10,202.0
1901	30	....	1,259,521	......	3	8,533,908	7,662	211	17,762.0
1902	....	128	1,386,881	......	....	9,495,673	7,549	...	20,970.3
1903	....	....	1,542,953	......	6	9,916,086	9,507	71	28,364.3
1904	....	....	1,537,838	......	....	9,671,180	9,203	196	34,042.3
1905	....	....	1,585,756	15	4	10,189,093	10,883	55	36,695.0
1906	....	....	1,613,301	5	....	11,050,219	9,300	16	43,251.5
1907	100	....	1,860,305	15	57	9,865,766	8,847	5	48,603.5
1908	5	....	1,890,751	2	13	9,755,303	5,618	*Nil.*	53,834.8
1909	2	....	1,941,923	......	5	9,765,575	8,382	6	56,410.0

(a) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (b) The exports are stated to be identical with the production, with the exception of coal, the exports of which were as follows: In 1896, 80,796 long tons; in 1897, 77,280 tons; in 1898, 57,333 tons; in 1899, 90,912 tons; in 1900, 116,216 tons; in 1901, 162,197 tons; in 1902, 191,696 tons; in 1903, 154,769 tons; in 1904, 165,220 tons; in 1905, 122,817 tons; in 1906, 141,641 tons; in 1907, 128,960 tons; in 1908 100,502 tons, and in 1909, 201,685 long tons. (c) Where gold is reported £1=$4.866.

MINERAL PRODUCTION OF VICTORIA. (*a*)

(In metric tons or dollars.)

Year.	Coal.	Lignite.	Gold. (*c*)	Building Stone, etc.	Tin Ore.
1896	230,187	5,908	$16,640,997	$485	47
1897	240,057	4,894	16,799,824	(*e*)125,000	48
1898	246,845	2,915	17,305,547	100,000	87
1899	266,578	(*b*)	17,662,410	(*b*)	158
1900	215,052	(*b*)	16,767,261	175,000	71
1901	212,678	152	16,320,029	225,000	78
1902	228,777	(*b*)	14,899,876	266,975	10
1903	65,230	5,752	15,860,815	213,245	34
1904	123,695	*Nil.*	15,824,952	1,488,075	72
1905	157,648	*Nil.*	15,443,438	(*b*)	126
1906	163,201	*Nil.*	15,962,804	(*f*) 362,725	108
1907	140,802	*Nil.*	14,377,166	(*f*) 401,090	105
1908	115,283	*Nil.*	13,867,312	(*f*) 453,075	80
1909	130,230	*Nil.*	13,522,400	(*b*)	90

(*a*) From Annual Reports of the Secretary for Mines of the Colony. (*b*) Not reported (*c*) Where gold is reported. £1=$4.866. (*e*) Estimated value. (*f*) Includes crude salt.

MINERAL PRODUCTION OF WESTERN AUSTRALIA. (*a*)

(In metric tons or dollars.)

Year.	Antimony.	Coal.	Copper Ore.	Gold. (*b*) (*c*)	Iron Ore.	Lead Ore.	Limestone.	Silver. *Kg.*	Tin Ore.
1900	....	120,305	6,282	$27,461,865	12,448	272	16,183	894	836
1901	....	119,721	10,319	32,698,941	20,898	(*d*) 21	18,501	1,893	746
1902	....	143,145	2.298	37,026,119	4,877	(*d*) 36	5,162	2,590	630
1903	22	135,568	20,854	40,560,927	224	*Nil.*	1,301	5,229	830
1904	....	140,773	4,033	39,557,933	1,465	*Nil.*	13,612	12,416	869
1905	....	129,402	2,389	38,045,366	3,264	*Nil.*	9,291	11,189	1,096
1906	*Nil.*	152,151	7,548	35,888,278	1,300	*Nil.*	9,624	8,776	1.518
1907	25	144,651	19,282	35,087,500	1,112	(*d*) 214	3,660	5,887	(*e*) 1,526
1908	*Nil.*	178,061	8,427	34,061,426	*Nil.*	(*d*) 526	*Nil.*	5,240	(*e*) 1,111
1909	*Nil.*	217,741	7,071	32,973,349	*Nil.*	(*d*) 214	*Nil.*	5,500	(*e*) 709

(*a*) From the *Report of the Department of Mines of Western Australia.* (*b*) £1=$4.866. (*c*) The value of gold produced in 1895 was $4,280,855; in 1896, $5,200,821; in 1897, $12,481,176; in 1898, $19,418,735. (*d*) Silver-lead ore. (*e*) Includes ingots

MINERAL IMPORTS OF AUSTRALIA. (*a*)

(In metric tons, cwts. of 112 lb., or dollars; £1=$5.) (*b*)

Year.	Cement. *Cwts.*	Coal.	Coke.	Copper Ore. *Cwts.*	Gold. (*b*)				
					Ore.	Bullion.	Specie.	Foil. (*c*)	Total Value.
1900	1,182,442	7,714	44,169	31,386	$ 14,880	$4,556,007	$ 78,888	$51,224	$4,700,999
1901	1,422,647	10,141	36,814	14,520	37,473	3,709,848	18,053	34,704	3,800,078
1902	1,074,482	5,149	9,846	29,236	2,375,513	3,834,510	505,899	30,028	6,740,950
1903	954,606	389	4,294	5	66,908	5,935,800	6,530	38,680	6,047.918
1904	561,237	398	4,270	12	68,309	5,684,164	6,297	43,215	5,801,985
1905	700,245	7,866	5,553	80	103,709	7,067,534	422,127	52,144	7,645,514
1906	793,928	706	6,202	873	93,116	10,053,463	397,990	53,356	10,597,925
1907	513,326	14,973	9,981	3,652	136,520	6,942,940	48,499	45,283	7,173,242
1908	915,033	14,833	10,368	3,959	42,855	4,625,498	70,197	....	4,738,550
1909	848,337	16,044	44,668	4,533	36,670	4,865,436	56,280	118,240	5,076,626

Year.	Graphite. Cwts.	Iron and Steel.			Lead Mfrs. Cwts.	Petroleum Products.		
		Bars, Rods, Girders, Sheets etc. *Cwts.*	Galvanized Plates and Sheets. *Cwts.*	Pig and Scrap. *Cwts.*		Kerosene. *Gal.*	Naphtha. *Gal.*	Paraffin.
1900	3,020	2,223,731	983,399	985,265	....	11,125,905	48,863	1,275
1901	3,419	2,081,423	905,709	732,512	....	20,924,640	114,092	1,040
1902	2,659	....	1,104,701	766,725	8,300	10,399,931	116,170	1,913
1903	5,557	1,211,437	886,570	989,998	9,525	15,009,609	127,445	2,163
1904	4,263	1,399,783	1,027,859	883,397	6,243	14,791,319	277,737	530
1905	4,386	1,482,334	1,112,467	940,757	8,859	16,416,734	292,670	....
1906	6,531	1,878,851	1,245,211	1,220,236	14,830	15,473,570	488,961	....
1907	6,991	2,045,184	1,502,790	1,276,566	2,940	19,273,955	683,679	2,758
1908	....	2,153,528	(*d*)1,253,624	820,834	2,703	17,154,940	782,859	1,560
1909	....	2,559,798	(*d*)1,658,291	1,178,219	19,338	19,924,622	884,703	2,767

Year.	Potassium Nitrate. *Cwts.*	Quick-silver.	Salt. *Cwts.*	Silver. (*b*)			Sulphur. *Cwts.*	Spelter, Sheets, Concentrates, Dross, etc. *Cwts.*
				Ore. *Cwts.*	Bullion. *Kg.*	Specie.		
1900	8,142	63.2	486,457	190	190.4	$1,226,208	109,647	13,582
1901	6,559	91.0	560,560	16,385	14.9	772,020	99,270	14,291
1902	7,955	92.6	571,548	5,562	13.6	439,186	173,176	20,965
1903	4,659	87.5	312,681	....	14.2	160,111	180,719	14,197
1904	7,812	92.6	355,599	....	39.8	154,534	252,744	23,316
1905	9,010	82.1	492,727	....	3908.0	261,397	177,304	26,211
1906	8,112	78.6	326,042	380	9756.4	703,820	269,704	24,233
1907	8,571	59.5	409,852	2	11.4	1,829,309	264,060	24,026
1908	6,036	56.4	390,535	....	189.8	1,019,738	420,098	38,724
1909	6,894	58.1	234,092	....	622.1	157,352	405,396	59,475

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1=$4.866. (*c*) Includes silver and other foils. (*d*) Includes ungalvanized corrgugated.

MINERAL EXPORTS OF AUSTRALIA. (*a*)

(In metric tons, cwts. of 112 lb., or dollars; £1 = $5.)

Year.	Alunite. *Cwts.*	Antimony Ore. *Cwts.*	Bismuth Ore. *Cwts.*	Cement. *Cwts.*	Chrome Ore. *Cwts.*	Coal.	Coke.	Cobalt Ore. *Cwts.*	Copper.	
									Ore. *Cwts.*	Ingot and Matte. (*Cwts.*)
1900	38,300	5,197	194	....	48,300	1,774,980	6,005	2,865	90,589	350,362
1901	62,920	2,206	993	....	41,035	1,750,066	4,465	2,212	231,644	389,041
1902	72,880	1,428	136	....	10,000	1,687,621	6,080	748	165,149	464,715
1903	49,690	947	832	11,168	39,022	2,063,016	27,345	3,060	61,569	616,277
1904	7,400	2,177	1,918	26,305	7,941	1,637,113	2,771	167	90,098	540,998
1905	54,040	7,811	2,222	17,283	(*c*)	2,058,190	2,316	1,320	17,380	632,183
1906	37,120	66,188	1,574	39,737	(*c*)	2,094,793	11,382	......	33,476	744,357
1907	41,750	74,440	653	75,600	54,503	2,689,917	35,063	......	157,071	853,236
1908	21,640	23,931	1,396	49,116	22,300	2,601,944	28,068	......	103,694	765,298
1909	73,795	14,976	1,763	23,585	....	1,608,161	24,798	280	163,612	676,664

Year.	Gold. (*b*)				Iron and Steel. Bars, Rods, etc. *Cwts.*	Lead.		
	Ore.	Bullion.	Specie.	Total Value.		Pig and Matte. *Cwts.*	Argentiferous. *Cwts.*	Manufactures. *Cwts.*
1900........	$2,379	$19,604,657	$41,898,304	$61,505,340	6,263	379,259	655,129	21,797
1901........	65,341	22,416,198	43,233,515	65,715,054	4,396	281,391	668,955	22,611
1902........	1,214,208	20,736,800	41,954,939	63,905,947	3,182	365,830	638,359	17,429
1903........	80,591	29,691,889	53,634,629	83,407,109	5,753	633,816	553,308	28,783
1904........	46,894	27,073,767	49,284,833	76,405,494	4,952	1,626,292	790,435	20,552
1905........	49,507	25,788,574	27,523,288	53,361,369	4,821	1,302,428	753,008	34,629
1906........	20,296	24,113,950	47,937,681	72,071,927	11,560	1,031,605	781,426	20,358
1907........	17,513	(*e*)19,639,502	33,370,240	53,027,255	13,163	1,774,207	....	21,765
1908........	20,539	(*e*)18,924,716	50,794,544	69,739,799	13,015	2,132,199	......	20,161
1909........	270,131	(*e*)17,265,872	26,028,555	43,564,558	12,040	1,381,369	......	14,067

Year.	Molybdenum Ore. *Cwts.*	Salt. *Cwts.*	Shale Oil.	Silver.		Tin.		Spelter, Sheets, Concentrates, Dross, etc. (*e*) *Cwts.*
				Ore. (*d*) *Cwts.*	Bullion. *Kg.*	Ore. *Cwts.*	Block. *Cwts.*	
1900............	......	100,893	16,792	1,598,789	192,328	6,815	72,172	37,352
1901............	......	156,760	19,587	1,630,252	196,136	5,012	60,129	1,732
1902............	160	238,192	27,896	1,439,374	189,703	10,291	63,424	4,461
1903............	783	155,613	14,483	1,653,794	202,730	26,900	82,473	60,206
1904............	1,100	141,553	8,202	2,235,385	227,972	40,339	99,476	309,422
1905............	1,381	174,987	11,818	581,651	208,134	55,153	108,963	3,006,372
1906............	1,867	198,851	7,203	1,010,707	174.457	51,793	130,120	2,592,018
1907............	2,025	189,194	5,686	907,790	294,679	65,005	131,407	5,393,784
1908............	2,116	240,348	19,173	1,137,746	326,250	49,409	121,979	6,235,024
1909............	1,055	230,486	3,983	1,914,479	90,989	8,559	111,262	6,994,745

(*a*) From "Trade and Customs Returns," Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (*b*) Where gold or silver values are reported £1=$4.866. (*c*) Included with iron ore. (*d*) Includes lead ore. (*e*) Includes gold contained in matte.

AUSTRIA-HUNGARY.

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA. (*a*)
(In metric tons.)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1895	885	5,716	695	296	404	185.0	9,722,679	18,389,147
1896	919	25,184	905	422	390	*Nil*	9,899,522	18,882,537
1897	851	21,585	864	425	300	1.0	10,492,771	20,458,093
1898	1,037	28,914	679	343	643	*Nil*	10,947,522	21,083,361
1899	604	19,879	410	271	2,635	0.3	11,455,139	21,751,794
1900	620	3,004	201	153	887	4.0	10,992,545	21,539,917
1901	442	2,551	126	114	541	16.0	11,738,840	22,473,510
1902	62	2,866	18	24	897	8.0	11,045,039	22,139,683
1903	*Nil*	2,978	41	14	1,273	10.0	11,498,111	22,157,521
1904	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
1907	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
1908	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926

Year.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast
1895	7,435	865	246	160	104	$49,841	28,443	1,384,911	660,549
1896	6,823	1,001	265	170	416	46,386	35,972	1,448,615	693,188
1897	7,405	1,083	276	125	647	44,924	38,504	1,613,876	762,685
1898	6,791	1,041	209	360	448	47,515	33,062	1,733,649	837,767
1899	6,731	1,123	235	475	387	50,306	31,819	1,725,143	872,352
1900	5,825	881	234	474	227	47,183	33,663	1,894,458	879,132
1901	7,406	776	256	472	143	31,234	29,992	1,963,246	884,844
1902	8,455	914	248	271	74	4,652	29,527	1,742,498	991,827
1903	12,688	961	310	298	2,148	5,316	29,590	1,715,984	970,832
1904	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
1908	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897

Year.	Lead.			Manganese Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1895	12,919	8,085	2,034	4,352	3,164	188,634	86,683	535	278,875
1896	14,563	9,769	1,738	3,950	3,979	262,356	83,305	564	308,933
1897	14,145	9,680	1,626	6,012	3,653	275,204	88,238	532	331,084
1898	14,363	10,340	1,520	6,132	3,213	323,142	88,519	491	341,959
1899	12,820	9,736	1,526	5,411	2,055	309,590	92,323	536	342,059
1900	14,314	10,650	1,288	8,804	2,828	347,213	94,747	510	330,277
1901	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
1902	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
1903	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904	22,514	12,645	783	10,189	1,829	....	88,279	536	369,877
1905	23,339	12,968	865	13,788	798	....	86,856	520	343,375
1906	19,683	14,846	1,059	13,402	943	....	91,494	526	378,912
1907	22,792	13,598	863	16,756	1,091	....	89,370	527	395,053
1908	21,513	12,669	1,010	16,656	475	....	90,145	572	388,133

Year.	Silver.		Sulphuric Acid.	Sulphur Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. (*Kg.*)			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1895	18,113	40,081	7,431	830	24	60	35	31	4.5	25,862	6,456
1896	18,701	39,904	7,972	643	15	54	22	30	4.2	26,887	6,888
1897	20,628	40,026	8,515	530	16	48	31	44	4.4	27,463	6,236
1898	20,886	40,304	7,003	496	13	48	36	51	4.3	27,395	7,302
1899	21,554	39,564	7,814	555	54	41	50	49	7.6	37,100	7,192
1900	21,641	39,572	7,067	862	51	40	50	52	11.3	38,243	6,742
1901	21,363	40,205	7,073	4,911	42	49	45	48	13.0	36,072	7,558
1902	22,288	39,544	8,781	3,721	47	50	45	46	10.0	31,927	8,309
1903	21,958	39,812	9,105	4,475	57	34	49	45	6.0	29,544	8,949
1904	21,949	39,032	8,742	6,288	77	38	52	17	11.0	29,226	9,159
1905	21,047	38,453	1,007	8,407	52	53	55	16	13.9	29,983	9,326
1906	21,944	38,940	745	15,125	55	42	56	16	16.1	32,037	10,804
1907	22,636	38,742	*Nil*	24,099	53	47	44	11	11.2	31,970	11,208
1908	22,241	39,867	*Nil*	17,429	68	39	37	9	8.4	31,266	12,770

(*a*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY. (*a*)

(In metric tons or dollars; 1 crown=$0.203.)

Year.	Antimony.		Asphalt.	Asphaltic Rock.	Bismuth	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (*d*)	Lignite. (*d*)	Coke.	Briquets.
1895	1,240	465	2,285	....	....	237	1,068,046	3,517,901	12,033	29,421
1896	1,361	500	2,740	....	....	352	1,132,625	3,761,728	25,550	31,179
1897	1,800	523	3,057	....	4.7	432	1,118,024	3,870,530	(*c*)	27,022
1898	2,201	855	3,125	....	3.1	771	1,239,498	4,516,581	(*c*)	31,781
1899	1,965	940	3,060	....	3.0	1,120	1,238,855	4,292,584	10,336	31,137
1900	2,373	846	2,700	....	2.0	1,250	1,447,047	5,128,277	12,973	69,353
1901	(*b*) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902	(*b*) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903	(*b*) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908	1,316	(*c*)	4,818	72,972	(*c*)	2,966	982,017	7,034,499	141,954	109,178

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese Ore.
				Ore. (*d*)	Pig.	Cast.	Ore.	Pig.		
1895	286	521	$2,118,100	9,955,262	322,206	....	.....	2.277	615	3,525
1896	159	595	2,131,876	1,269,680	383,698	....	.....	1,911	465	2,101
1897	213	592	2,038,839	1,421,130	402,503	....	525	2,527	155	4,030
1898	153	745	1,839,474	1,666,837	448,621	20,784	771	2,305	188	8,087
1899	165	771	2,039,504	1,587,600	451,637	19,631	526	2,166	213	5,073
1900	181	700	2,173,079	1,666,363	432,817	22,738	612	2,030	201	5,746
1901	162	805	2,189,692	1,557,300	430,686	20,640	(*b*) 10	2,029	238	4,591
1902	89	909	2,260,135	1,562,238	416,835	18,569	(*b*) 20	2,244	219	7,237
1903	45	982	2,243,521	1,439,132	396,674	18,875	(*d*)3,698	2,057	257	5,311
1904	63	1,277	2,437,998	1,524,036	370,297	17,203	(*d*)3,922	2,104	710	11,527
1905	73	920	2.439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7.176
1907	85	1,212	2,330,292	(*e*) 622,518	423,134	17,103	8	1,468	441	8,198
1908	166	1,372	2,189,801	(*e*) 727,019	505,559	17,415	3	1,544	190	10,601

Year.	Mineral Paints.	Petroleum.	Pyrites.	Quick-silver. *Kg.*	Salt.	Silver. *Kg.*	Sulphur	Sulphuric Acid.	Zinc.	
									Ore. (*b*)	Spelter.
1895......	371	2,083	69,195	1,129	169,395	20,432	102	4,223	(*d*)	....
1896......	334	2,168	52,697	1,100	180,133	19,916	138	3,550	(*d*)	....
1897......	460	2,229	44,454	700	193,463	26,790	112	3,397	30	....
1898......	247	2,471	58,079	6,800	197,593	18,799	93	1,318	30	....
1899......	394	2,125	79,519	27,000	200,525	20,991	116	1,463	1,197	....
1900......	370	2,199	87,000	31,800	212,957	20,202	123	13,71	326	....
1901......	305	3,296	93,907	33,003	215,581	23,636	137	1,464	693	14
1902......	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	....
1903......	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904......	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	....
1905......	196	471	106,848	36,000	238,642	15,946	135	1,410	173	....
1906......	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
1907......	259	2,404	99,503	40,400	(*c*)	12,695	(*c*)	1,232	(*c*)	(*c*)
1909......	294	2,427	95,824	78,000	(*c*)	12,612	144	1,444	135	(*c*)

(*a*) From the *Annuaire Statisque Hongrois.* (*b*) Includes only that part of the crude output that was not smelted into a refined product. (*c*) Not reported. (*d*) Total production. (*e*) Exported.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA. (*a*)
(In metric tons.)

Year.	Chrome Ore.	Copper.		Iron.		Lignite.	Manganese Ore.	Pyrites.	Quick-silver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
1895......	707	(*b*)	105	(*b*)	2,569	195,422	8,145	....	(*b*)	12,758
1896......	443	(*b*)	206	(*b*)	10,120	222,724	6,821	....	(*b*)	13,720
1897......	396	3,847	135	37,095	15,606	229,643	5,344	....	(*b*)	13,919
1898......	458	3,760	156	57,935	15,263	270,752	5,320	3,760	4.0	14,496
1899......	200	3,980	180	67,030	13,730	303,000	5,270	....	3.3	15,030
1900......	100	3,008	141	133,454	38,960	394,516	7,939	1,710	6.7	15,791
1901......	505	3,696	199	122,569	39,296	445,007	6,346	4,570	9.3	16,865
1902......	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903......	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904......	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905......	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(*b*)
1906......	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907......	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148

(*a*) From *Oestr. Zeit. f. B.-u. H.* (*b*) Not reported.

MINERAL EXPORTS OF AUSTRIA-HUNGARY. (*a*)
(In metric tons or dollars; 5 crowns=$1.)

Year.	Alum.	Aluminum, Sulphate and Chloride.	Antimony.		Arsenic, Metallic, Oxide, Orpiment and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1895........	60	231	193	369	36	122	10	145	1,183
1896........	47	267	218	441	26	48	10	134	1,692
1897........	70	210	289	359	16	56	19	102	2,593
1898........	83	253	266	679	29	150	28	183	2,126
1899........	54	233	562	240	47	71	60	1,143	2,619
1900........	44	164	247	276	65	47	168	1,218	2,177
1901........	55	211	179	385	80	36	165	198	1,909
1902........	102	135	174	290	89	65	275	520	301
1903........	77	14	128	249	63	89	495	921	483
1904........	38	2	200	673	72	290	1,582	403	728
1905........	68	34	....	774	42	330	1,397	1,060	457
1906(*f*)......	68	80	....	912	66	376	1,708	2,824	799
1907........	75	81	....	698	59	351	630	3,787	771
1908........	147	92	....	527	51	442	450	1,312	1,030

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate. (*b*)	Chloride.					Bituminous.	Lignitic.	
1895	....	....	267	12,804	385	56,203	640,963	7,143,234	119,051
1896	....	....	114	16,721	142	67,381	658,368	7,562,721	116,608
1897	....	....	111	19,786	153	68,609	701,919	8,108,975	145,056
1898	....	....	113	23,989	121	74,003	824,730	8,351,955	194,289
1899	65	....	203	38,193	53	78,537	879,337	8,662,788	252,971
1900	23	....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906 (*f*)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets Plates, etc.			
1895	44	17	151	354	162	301	11
1896	40	12	228	189	47	392	2
1897	27	0.1	159	180	14	648	10
1898	22	12	173	266	29	539	23
1899	309	74	534	298	67	808	101
1900	45	801	471	200	57	748	237
1901	6	1,042	435	334	23	548	231
1902	42	1,018	436	381	44	857	363
1903	12	1,308	1,226	451	45	898	521
1904	36	574	747	577	50	1,170	574
1905	5	2,328	1,253	746	49	836	638
1906(*f*)	*Nil.*	341	1,007	816	99	861	*Nil.*
1907	*Nil.*	489	624	870	11	1,580	*Nil.*
1908	7	206	1,126	788	63	2,199	*Nil.*

Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (*e*)	Specie. (*e*)		Crude.	Calcined.	
1895	1	$203,352	$8,885,815	11,923	1,496	1,439	1,460
1896	45	253,194	13,555,706	13,091	899	1,376	1,246
1897	37	158,827	18,598,931	14,229	662	1,804	1,439
1898	13	17,943	23,779,858	17,109	718	2,163	1,614
1899	67	17,864	12,711,454	19,451	634	1,539	1,495
1900	1	120,988	11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1059	9,338	10,995,089	18,535	363	1,652	4,085
1906 (*f*)	936	88,264	8,015,967	16,871	1,970	686	2,942
1907	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720

Year.	Iron.				Lime.	Magnesium. Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire etc.			
1895	165,402	9,786	18,698	9,993	34,098	661	(*c*)
1896	214,390	11,712	17,674	12,428	76,895	2,291	(*c*)
1897	247,856	12,084	21,064	17,387	83,110	6,910	(*c*)
1898	302,317	15,803	22,724	23,231	89,067	7,248	(*c*)
1899	326,951	27,738	30,822	50,197	85,570	5,721	(*c*)
1900	263,421	53 426	40,344	65,019	86,273	7,321	(*c*)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906 (*f*)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,399	69,669	89,305	6,905	113,695
1908	220,357	17,494	31,674	29,227	62,938	2,622	87,049

Year.	Lead. Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel and Cobalt ores.
1895	3,758	118	782	208	24	233	425	1,977	2,244	139
1896	3,076	113	597	272	33	171	701	1,831	1,700	113
1897	2,438	114	355	241	24	47	622	1,773	1,621	117
1898	2,253	100	188	545	45	55	1,961	2,109	2,153	121
1899	2,502	99	188	258	45	41	1,127	1,904	2,061	75
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	26
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906 (f)	4,891	223	302	602	16	52	4,170	1,763	1,367	42
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	*Nil.*

Year.	Nitric Acid.	Ozokerite.	Peat and Peat coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrites.	Sulphur.
1895	418	5,054	3,753	5,317	....	....	5,665	1,074	383	989
1896	360	5,722	2,701	24,921	....	....	4,164	1,026	341	1,231
1897	310	5,153	1,655	14,682	....	....	5,997	1,005	255	947
1898	294	4,462	3,400	4,138	....	....	7,252	994	3,039	923
1899	420	5,441	4,010	11,756	20,646	10	10,113	974	5,201	885
1900	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906 (f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998

Year.	Sulphuric Acid.	Tin. Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.	Whetstones.	Zinc. Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross
1895	6,466	53	90	248	2,169	7,491	504	1,158	1,688	179
1896	6,212	130	78	281	2,035	9,453	1,256	1,139	1,825	277
1897	7,903	87	75	306	2,323	12,914	770	993	1,673	197
1898	9,880	96	72	324	2,316	14,065	1,184	757	1,240	298
1899	12,422	167	77	273	2,215	20,461	1,614	1,313	1,096	73
1900	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903	8,369	292	111	158	2,569	15,108	4,420	729	3,446	267
1904	9,101	126	102	123	2,159	17,314	4,,606	532	3,666	158
1905	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906 (f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	(g)
1907	15,190	333	84	160	1,900	19,516	4,608	347	4,873	(g)
1908	13,581	257	49	172	2,009	19,233	6,604	173	4,131	(g)

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes artificial barium sulphate. (c) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (d) From 1895 to 1898 inclusive, includes crude and refined petroleum; from 1899 to 1905 inclusive, lubricating oil is also included. (e) Where gold or silver values are reported 1 crown=$0.203. (f) Last 10 months only. (g) Not reported.

MINERAL IMPORTS OF AUSTRIA-HUNGARY. (*a*)
(In metric tons or dollars; 5 Crowns=$1.)

Year.	Alum.	Aluminum and Alloys.	Aluminum, Sulphate and Chloride.	Antimony.		Arsenic. (*b*)	Asbestos.	
				Ore.	Regulus—*Kg.*		Crude. (*c*)	Manufactures
1895	338	48	1,278	15	2,100	293	432	108
1896	359	50	1,128	16	700	309	185	165
1897	346	67	1,351	8	600	259	625	134
1898	338	101	1,822	12	28,200	287	609	138
1899	332	121	1,299	10	30,400	284	866	1347
1900	430	154	1,435	46	23,000	320	1,085	1238
1901	413	153	1,882	27	1,500	351	1,678	1032
1902	537	151	2,161	40	18,200	351	2,038	798
1903	508	150	2,670	42	87,200	371	3,395	1221
1904	602	231	2,346	64	21,000	384	2,517	1240
1905	774	477	2,775	......	24,700	342	5,962	208
1906 (*f*)	513	216	2,840	......	38,900	83	7,025	111
1907	545	255	3,200	......	89,900	325	5,729	173
1908	567	323	2,606	......	128,200	349	9,484	168

Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude and Boric Acid.	Refined.			
1895	2,410	872	5,098	1,908	62	32,012	2,538	1,827
1896	4,715	1,621	5,377	1,363	76	35,290	1,989	1,891
1897	5,824	1,309	4,947	1,206	63	32,479	1,820	1,109
1898	5,973	1,117	5,012	784	185	30,745	2,851	2,206
1899	7,301	1,546	5,443	2,212	130	21,410	3,749	1,874
1900	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902	5,732	1,273	6,266	2,168	174	18,658	2,596	2,668
1903	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904	8,211	1,064	6,238	2,752	142	20,259	3,407	1,209
1905	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906 (*f*)	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate.
		Bituminous.	Lignitic.		Ore	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1895	6,532	4,503,003	16,797	533,402	31	11,747	98	895
1896	7,425	5,174,321	19,981	491,028	1	13,666	126	2,084
1897	6,913	5,121,475	19,609	533,463	81	15,926	94	6,822
1898	7,991	5,396,760	19,393	606,783	64	17,443	159	5,271
1899	8,152	5,296,700	20,879	564,005	*Nil*	16,185	156	2,345
1900	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,508
1905	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906 (*f*)	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908	17,417	9,995,415	30,433	851,099	121	33,270	1,185	8,402

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (*d*)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1895	871	229	3,528	$3,470,945	$17,384,964	640	850	10,916	467
1896	575	265	3,821	8,674,371	16,956,256	697	821	11,736	529
1897	401	211	4,201	22,374,069	18,164,128	948	980	12,101	721
1898	466	275	4,169	323,636	8,853,354	1,109	991	13,300	766
1899	409	343	4,959	432,187	7,662,641	815	1,336	13,441	350
1900	343	342	5,649	1,111,831	7,230,251	302	1,348	15,462	577
1901	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(*f*)	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908	74	564	7,359	7,402,982	7,766,538	755	4,993	10,842	924

Year.	Iron.				Lead.					
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig.	Alloys, Crude.	Litharge.	Red and Yellow.	White.
1895	117,600	175,400	$3,990,400	30,909	416	208	8,974	355	371	187
1896	107,018	148,217	4,258,400	27,809	540	218	7,221	233	432	156
1897	134,778	164,433	4,582,400	18,625	441	148	5,887	224	543	111
1898	178,507	173,919	4,627,200	26,421	459	153	9,746	280	555	115
1899	212,412	126,371	4,395,356	12,340	465	235	8,836	224	466	80
1900	233,156	95,530	4,533,599	10,313	501	175	7,916	141	354	106
1901	218,476	90,287	4,443,670	10,902	1,270	311	10,722	189	433	135
1902	197,525	43,314	4,304,818	11,584	1,879	348	8,706	149	428	221
1903	217,979	47,354	4,508,224	11,025	1,355	409	9,190	141	423	173
1904	182,515	35,091	4,976,342	9,402	1,436	349	7,917	146	372	138
1905	228,149	49,383	5,722,976	....	247	475	7,282	101	349	88
1906 (*f*)	232,558	57,341	6,153,698	5,085	189	....	6,989	82	310	75
1907	390,322	151,848	(*g*)27,937	29,268	204	....	9,967	98	381	126
1908	423,940	224,970	(*g*)44,295	88,396	559	....	14,465	161	616	201

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores.	Nitric Acid.	Peat and Peat Coke.
1895	1,353	2,772	1,229	4,244	168	1,020	16	1,993
1896	1,333	7,371	1,205	4,362	161	719	21	2,002
1897	1,530	8,018	1,275	4,553	157	55	23	2,189
1898	2,096	5,396	1,429	4,979	137	510	22	1,511
1899	2,043	5,855	1,458	5,106	119	198	39	2,075
1900	2,100	7,016	1,672	4,958	258	406	36	2,664
1901	2,529	6,367	1,595	5,109	277	788	22	2,896
1902	2,621	15,595	1,410	4,831	265	225	90	3,234
1903	3,118	38,529	1,395	4,733	268	385	7	3,097
1904	2,997	35,357	1,282	5,563	402	656	24	2,676
1905	3,495	30,483	1,467	6,018	632	391	14	2,432
1906 (*f*)	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908	5,011	31,023	1,474	8,909	1,521	1,114	11	6,459

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrites.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1895	120,479	16,876	.....	226	285	2,679	29	54,610
1896	69 013	17,943	.....	224	987	2,475	34	50,691
1897	70,573	21,249	.....	209	333	2,206	34	49,462
1898	58,580	22,299	.....	209	300	2,258	3	52,282
1899	75,885	21,823	6,968	221	526	3,264	1	54,844
1900	20,813	22,963	5,080	204	1,029	3,633	11	60,317
1901	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902	24,830	15,864	4,238	225	485	3,377	11	60,235
1903	19,710	19,382	2,598	237	197	3,727	9	73,835
1904	20,110	22,715	1,470	193	222	3,557	3	65,397
1905	18,974	24,961	888	222	154	3,864	5	86,338
1906 (*f*)	13,522	9,693	403	178	602	3,729	(*e*) 5	87,973
1907	18,345	11,441	524	219	114	4,807	(*e*) 38	130,270
1908	3,114	9,705	358	234	169	5,009	(*e*) 98	130,793

Year.	Quicksilver Kg.	Salt.	Silica, Quartz and Sand.	Silver. Bullion, Kg.	Silver. Specie.	Slag and Slag Wool.	Roofing Slate.
1895	4,200	40,396	58,494	49,370	$90,353	981	15,667
1896	1,300	53,680	59,150	138,420	137,244	240	15,932
1897	1,000	46,057	61,532	99,900	75,944	4,717	16,758
1898	6,300	41,870	70,296	15,400	103,424	9,655	16,025
1899	2,600	37,883	71,279	28,900	112,056	5,665	15,562
1900	1,300	39,822	77,930	29,300	199,955	4,679	13,047
1901	2,600	39,625	83,401	41,800	207,669	3,068	11,555
1902	1,300	46,128	92.617	177,900	237,104	4,176	14,378
1903	1,600	48,793	94,492	150,400	250,299	3,850	11,531
1904	2,500	94,103	97,364	36,700	420,413	4,716	9,170
1905	2,400	....	104,195	36,100	143,152	4,094	8,852
1906 (f)	1,800	32,182	134,526	43,000	200,754	....	6,020
1907	1,200	41,655	180,280	88,182	170,228	3,311	7.537
1908	2,000	57,566	177,529	96,700	98,301	2,941	7,178

Year.	Sodium Salts. Bi-Sulphate.	Carbonate.	Carbonate. (Calcined).	Hydrate.	Nitrate.	Sulphate.	Sulphur.
1895	137	40	551	1,163	43,059	6,617	14,709
1896	144	57	1,332	835	33,086	4,678	15,221
1897	91	45	2,787	1,450	39,600	2,879	21,406
1898	89	53	2,408	1,498	41,773	4,476	20,655
1899	85	62	1,123	1,669	47,301	5,394	23,504
1900	73	104	1,141	1,836	54,559	5,110	27,795
1901	98	77	911	1,280	63,283	4,452	25,300
1902	17	97	312	1,030	39,958	5,997	23,878
1903	13	110	327	956	54,896	6,116	22,625
1904	103	103	1,109	659	54,887	5,409	30,505
1905	167	168	965	475	66,740	5,258	30,227
1906 (f)	86	382	303	218	49,862	7,508	26,755
1907	72	153	283	305	57,023	7.342	34,261
1908	32	124	288	358	69,722	7,596	30,985

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whetstones.	Zinc. Calamine and Other Ores.	Zinc. Spelter.	Zinc. Bars, Sheets Wire, etc.	Zinc. White.
1895	1,566	3,038	3,559	7,691	17,156	611	510
1896	3,522	3,344	3,851	9,022	17,539	552	590
1897	5,877	3,467	4,151	7,863	16,599	356	577
1898	9,724	3,769	3,490	14,112	17,471	453	697
1899	10,245	3,005	3,717	12,730	15,225	481	750
1900	10,643	3,439	3,643	14,181	17,844	667	875
1901	11,712	3,671	3,445	18,403	16,921	579	718
1902	12,474	3,638	3,599	20,723	17,034	651	636
1903	16,148	3,564	3,774	22,344	17,973	746	698
1904	19,878	3,528	4,272	24,039	20.787	731	840
1905	17,320	3,845	4,376	22,890	21,874	568	972
1906 (f)	17,020	3,320	4,377	24,014	19,467	595	347
1907	20,430	4,433	5,552	24,289	24,092	604	219
1908	25,251	4,295	5,916	19,366	26,472	918	361

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets*. (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) Metric tons.

BELGIUM.

The mining and metallurgical production in Belgium, and the imports and exports, according to the latest official statistics, are as follows:

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM. (a)
(In metric tons except where otherwise noted.)

Year.	Barytes.	Chalk, Marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthenware.	
1896	25,000	191,100	21,252,370	1,213,760	2,004,430	23,450	307,031
1897	23,000	204,600	21,492,446	1,245,114	2,207,840	23,050	240,774
1898	21,700	287,805	22,088,335	1,351,884	2,161,162	22,150	217,370
1899	25,900	351,800	22,072,068	1,276,050	2,304,607	25,185	201,445
1900	38,800	377,550	23,462,817	1,395,910	2,434,678	25,700	247,890
1901	22,800	449,000	22,213,410	1,587,800	1,847,780	17,700	218,780
1902	33,000	390,700	22,877,470	1,616,520	2,048,070	17,430	166,480
1903	21,000	501,920	23,796,680	1,686,415	2,203,020	16,250	184,400
1904	60,000	450,400	22,761,430	1,735,480	2,211,820	18,070	206,730
1905	26,000	372,000	21,775,280	1,711,920	2,238,920	12,800	176,940
1906	22,365	568,170	23,569,860	1,887,090	2,414,490	14,900	232,570
1907	23,000	478,880	23,705,190	2,040,670	2,473,790	15,050	316,250
1908	25,070	352,690	23,557,900	2,341,210	2,307,990	15,430	188,780

Year.	Iron, Crude.					Iron, Manufactures of.			
	Forge Pig.	Foundry Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Merchant Bars.	Sheet and Plate.	Wrought	Other Mfres.
1896	362,451	84,275	193,518	307,779	959,414	81,394	112,597	851	298,163
1897	426,332	78,410	183,701	333,958	1,035,037	108,608	100,252	872	263,644
1898	308,875	93,645	173,085	397,891	979,755	123,993	91,686	993	267,521
1899	317,029	84,165	169,664	453,718	1,024,576	93,601	97,604	662	283,331
1900	305,344	88,335	176,557	447,271	1,018,561	61,458	73,572	1,411	284,591
1901	178,250	86,170	166,820	332,940	764,180	249,380	65,760	550	64,900
1902	104,540	254,710	199,170	510,630	1,069,050	260,290	62,740	450	58,150
1903	91,600	256,890	229,160	638,430	1,216,080	274,520	56,550	390	60,920
1904	99,350	224,410	217,390	742,040	1,287,597	246,240	41,000	370	67,580
1905	98,170	206,390	220,210	784,850	1,311,120	270,840	39,250	40	67,490
1906	96,090	218,225	177,900	870,860	1,375,775	265,010	37,540	20	55,680
1907	92,280	189,190	88,650	1,008,170	1,406,980	274,400	37,950	20	46,130
1908	116,740	76,290	78,950	996,870	1,270,050	239,670	30,130	20	36,830

Year.	Steel.					Lead.		Manganese Ore.
	Ingots, Blooms and Billets.	Rails.	Tires.	Wrought.	Plates.	Ore.	Pig.	
1896	598,947	147,183	10,497	6,702	64,653	70	17,222	23,265
1897	616,541	136,911	10,870	23,104	64,366	108	17,023	28,372
1898	653,523	117,751	10,953	17,902	87,219	133	19,330	16,440
1899	731,249	123,119	11,212	32,180	68,051	137	15,727	12,120
1900	655,199	134,428	11,934	25,985	55,307	230	16,365	10,820
1901	529,840	132,260	12,380	3,310	83,810	220	18,760	8,510
1902	786,980	(c)268,220	12,790	2,910	94,360	164	73,357	14,440
1903	988,160	(c)351,540	17,810	2,920	118,200	90	68,700	6,100
1904	1,065,870	(c)266,900	23,540	4,300	149,270	91	23,470	485
1905	1,227,110	241,640	25,810	6,080	179,470	126	22,885	*Nil.*
1906	1,440,860	274,920	32,070	5,070	186,610	121	23,765	120
1907	1,521,610	314,760	34,700	5,190	157,850	210	27,450	2,100
1908	1,198,000	(c)191,370	29,000	2,870	157,900	195	35,650	7,130

Year.	Mineral Paints. Ochers. *Cubic Meters.*	Phosphate of lime. *Cubic Meters.*	Pyrites	Slate. *Pieces*	Silver. *Kg.*	Zinc. Ore. (Blende)	Zinc. Ore. (Calamine)	Zinc. Spelter.	Zinc. Sheets.
1896.........	700	297,470	2,560	35,980,000	28,509	7,070	4,560	113,361	36,238
1897.........	350	350,056	1,828	41,422,000	30,073	6,804	4,150	116,067	37,011
1898.........	290	156,920	147	42,311,000	116,035	7,350	4,125	119,671	35,587
1899.........	300	190,090	283	44,167,000	134,854	5,736	3,730	122,843	34,289
1900.........	300	215,670	400	43,941,000	146,548	5,715	3,000	119,317	38,825
1901.........	(*b*)2,100	(*b*) 222,520	560	39,030,000	169,450	4,445	2,200	127,170	37,380
1902.........	(*b*) 200	(*b*) 135,850	710	37,120,000	212,249	3,568	284	124,780	37,070
1903.........	(*b*) 200	(*b*) 184,120	720	38,953,000	232,740	3,565	65	131,740	42,280
1904.........	(*b*) 450	(*b*) 202,480	1,075	41,240,000	252,920	3,698	4	137,323	41,490
1905.........	(*b*) 300	(*b*) 193,305	976	41,435,000	201,935	3,929	*Nil.*	142,555	45,320
1906.........	(*b*) 250	(*b*) 152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907.........	(*b*) 200	(*b*) 181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908.........	....	(*b*) 198,030	357	41,180,000	227,032	2,099	3	161,940	43,410

(*a*) From *Statistique des Industries Extractives et Métallurgiques et des Appareils à vapeur en Belgique.* (*b*) Metric tons (*c*) Includes beams.

CANADA.

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA. (a)
(In metric tons or dollars.)

Year.	Arsenic.	Asbestos and Asbestic	Barytes.	Cement—*Barrels.*		Chromite.	Coal.	Cobalt.	Coke.
				Natural Rock.	Portland.				
1896......	*Nil.*	11,113	132	70,705	78,385	2,124	3,398,091	....	45,004
1897.....	*Nil.*	27,617	518	85,450	119,763	2,392	3,434,756	....	55,042
1898......	*Nil.*	21,577	971	87,125	163,084	1,833	3,784,532	....	79,453
1899......	52	22,938	653	131,387	255,366	1,796	4,467,021	....	91,444
1900......	275	27,797	1,213	125,428	292,124	2,335	5,087,060	....	142,521
1901......	630	36,477	592	133,328	317,066	1,274	5,648,208	....	331,537
1902......	726	36,657	994	127,931	594,594	900	6,524,180	....	455,353
1903......	725	37,902	1,055	92,252	627,741	3,509	6,933,107	....	509,115
1904.....	(*d*) 66	44,131	1,253	51,555	771,650	5,511	6,812,834	....	493,107
1905.....	*Nil.*	61,928	3,049	14,184	1,346,547	7,781	7,961,397	....	622,154
1906......	*Nil.*	72,025	3,628	8,610	2,139,164	7,936	9,033,973	....	(*b*)
1907......	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	....	(*b*)
1908......	634	82,448	3,911	1,044	2,665,289	6,553	9,857,754	841	784,788
09 (*f*)...	1,024	79,197	(*b*)	(*b*)	4,010,180	(*d*)1,627	9,445,569	(*b*)	793,859

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (*c*)	Graphite.	Grindstones.	Gypsum.	Iron Ore.	Iron, Pig. All kinds.
1896.....	4,260	(*b*)	882	$2,754,774	126	3,368	187,778	83,359	61,012
1897.....	6,032	(*b*)	1,270	6,027,016	395	4,147	217,340	45,989	52,612
1898.....	8,048	(*b*)	2,268	13,775,420	1,107	4,476	198,864	52,917	69,853
1899.....	6,838	(*b*)	2,721	21,261,584	1,188	4,091	221,821	67,678	93,367
1900.....	8,588	3	288	27,908,153	1,743	5,024	228,656	110,654	87,594
1901.....	17,155	403	4,852	24,128,503	2,004	4,155	266,476	284,477	248,859
1902.....	17,598	697	6,871	21,336,667	993	5,835	301,165	366,431	324,617
1903.....	19,357	880	12,633	18,843,590	660	5,023	285,242	239,715	270,182
1904.....	19,497	834	10,057	16,400,000	410	4,091	309,133	317,387	275,367
1905.....	21,596	1,492	10,617	14,486,833	491	4,693	395,341	263,113	475,491
1906.....	25,863	2,063	14,397	12,023,932	405	5,029	378,904	269,842	550,628
1907.....	26,025	1,716	11,414	8,264,765	525	4,881	431,286	....	590,444
1908.....	28,895	988	7,144	9,842,105	227	3,285	309,254	184,565	572,284
1909 (*f*)..	24,549	1,353	9,331	9,790,000	662	3,597	425,062	(*d*)19,918	(*g*)686,886

Year.	Iron and Steel, Rolled.	Lead. (In ore, etc.)	Manganese Ore.	Mica.	Mineral Paints. (Ochers.)	NaturalGas.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (*e*)
1896..................	76,244	10,975	(*d*)112	$60,000	2,142	$276,301	1,541	726,822
1897..................	78,253	17,695	(*d*) 14	76,000	3,542	325,873	1,813	709,857
1898..................	101,748	14,469	45	118,375	2,019	322,123	2,502	758,391
1899..................	112,412	9,914	1,434	163,000	3,555	387,271	2,605	808,570
1900..................	102,301	28,648	27	166,000	1,783	417,094	3,211	710,498
1901..................	113,799	23,537	(*d*) 399	160,000	2,025	339,476	4,167	623,392
1902..................	164,069	10,411	(*d*) 156	135,904	4,494	195,992	4,849	530,624
1903..................	131,588	8,226	83	177,857	5,683	202,210	5,671	486,637
1904..................	(*b*)	17,241	(*d*)112	152,919	3,562	247,370	4,786	552,575
1905..................	(*b*)	25,391	(*d*) 20	168,170	4,632	314,249	8,565	634,095
1906..................	(*b*)	24,580	(*d*) 84	(*d*) 581,043	6,201	528,868	9,745	569,753
1907..................	(*b*)	21,570	......	333,022	7,115	748,541	9,610	788,872
1908(*f*)..............	(*h*)534,117	19,593	......	139,871	4,305	1,012,660	8,685	527,987
1909(*f*)..............	(*h*)684,670	20,819	......	154,106	(*b*)	1,205,943	11,921	420,755

Year.	Phosphate (Apatite).	Pyrites.	Salt.	Silver—*Kg.* (In ore, etc.)	Soapstone and Talc.
1896	517	30,580	39,872	99,699	372
1897	824	35,291	46,574	172,891	142
1898	665	29,223	51,828	138,486	367
1899	2,721	25,112	53,820	106,116	408
1900	1,283	36,308	56,284	138,980	1,288
1901	937	31,982	53,901	172,292	235
1902	776	32,304	58,462	133,478	625
1903	1,205	30,822	56,644	99,489	898
1904	832	29,980	62,411	115,666	762
1905	1,180	29,713	41,159	185,839	454
1906	(*b*)	35,927	69,283	266,521	1,119
1907	680	35,494	65,936	390,359	1,391
1908	1,447	42,934	72,537	687,504	976
1909(*f*)	542	51,744	76,237	867,024	4,088

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*f*) From preliminary unrevised reports. (*g*) From Canadian ore, 149,444, short tons. (*h*) Steel ingots and castings.

MINERAL IMPORTS OF THE DOMINION OF CANADA. (*a*.)

(In metric tons or dollars.)

Year. (*b*)	Aluminum.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures.(*m*)	Ingots, Sheets, etc.					
1897	$5,717	....	61	68	$19,032	342	$ 260,842
1898	7,102	....	71	132	26,389	6,006	365,624
1899	9,275	....	131	264	32,607	8,196	477,617
1900	12,543	....	90	105	43,455	2,825	513,770
1901	16,202	....	159	72	50,829	2,849	666,350
1902	30,496	....	229	48	52,464	3,426	863,646
1903	14,201	$ 13,930	393	135	75,465	3,037	890,745
1904	16,065	101,427	190	188	83,827	7,093	1,014,713
1905	28,418	154,569	85	122	116,836	5,096	1,263,828
1906	23,565	168,405	183	202	138,000	7,178	1,003,022
1907(*o*)	20,656	218,399	146	158	127,509	11,929	540,006
1908(*r*)	37,197	131,762	220	228	191,204	14,113	865,275
1909(*r*)	30,076	167,019	201	58	181,710	15,979	473,211

Year.	Coal.		Coke.	Copper. Ingots, Pig and Scrap.	Copper. Sulphate	Gold and Silver. Coin and Bullion. (*g*)
	Anthracite. (*f*)	Bituminous. (*f*)				
1897	1,321,767	1,604,517	75,580	22	516	$ 4,676,094
1898	1,324,856	1,735,576	122,499	476	738	4,390,844
1899	1,583,132	2,220,250	128,145	751	726	4,705,134
1900	1,500,542	2,512,334	170,405	519	752	8,297,438
1901	1,753,488	2,658,257	280,069	432	673	3,537,294
1902	1,498,773	3,208,005	242,298	801	711	6,311,405
1903	1,320,239	3,684,502	232,848	924	1,010	8,976,797
1904	2,064,444	4,230,436	200,590	960	795	7,874,313
1905	2,361,952	4,377,667	337,035	882	934	10,308,435
1906	1.996,183	5,003,029	435,561	1,191	844	7,078,603
1907(*o*)	1,260,723	4,022,843	363,286	1,186	897	7,029,047
1908(*r*)	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
1909(*r*)	2,775,680	6,526,797	423,013	1,239	963	9,988,442

Year.	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures. (h)	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms, Bars, Etc.	Alloys of Iron.
1897	$1,406	$38,537	482	440	33,442	2,566	387
1898	1,862	52,291	1,057	150	81,577	7,391	1,287
1899	4,979	57,824	310	225	69,819	5,640	1,053
1900	4,437	60,518	72	385	94,489	11,576	1,043
1901	2,357	75,536	289	228	59,033	10,659	1,372
1902	3,649	64,123	516	215	71,882	18,208	5,910
1903	2,870	69,676	1,007	286	129,641	17,896	5,762
1904	1,802	67,563	626	291	86,087	9,088	2,700
1905	2,499	75,288	2,972	3,595	90,698	14,420	11,738
1906	2,791	86,028	5,743	6,579	112,937	29,520	13,626
1907(o)	3,176	57,430	8,334	9,730	137,654	17,369	17,785
1908(r)	3,030	78,380	8,519	6,955	190,994	35,534	16,139
1909(r)	1,408	75,608	9,359	7,712	72,966	42,146	13,571

Year.	Kainite.	Lead.				Lime.		Mineral Paints. (Ochers)
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride of.	
1897	206	2,962	477	546	4,678	16,108	1,361	682
1898	49	4,012	1,008	519	5,754	12,850	1,765	965
1899	30	5,202	2,032	432	6,583	15,720	1,857	1,110
1900	143	2,829	703	415	6,661	12,865	1,967	1,122
1901	88	(i) 3,871	739	505	4,647	19,657	1,605	1,031
1902	85	(i) 5,548	844	590	7,071	24,602	1,806	1,148
1903	259	(i) 4,471	523	632	8,715	31,108	2,104	1,459
1904	339	4,292	....	....	7,679	54,359	2,080	1,256
1905	306	2,589	800	811	9,695	98,676	2,507	1,417
1906	306	3,751	730	461	6,947	134,334	2,645	809
1907 (o)	511	3,811	622	513	2,215	88,919	2,302	570
1908 (r)	743	2,902	782	864	5,743	129,379	3,421	788
1909 (r)	562	2,273	623	550	3,998	153,934	2,697	546

Year.	Nickel.	Petroleum Products—*Gallons.*		Platinum.	Potassium Salts.		Quicksilver.
		Illuminating oil, etc., Crude or Refined.	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1897	$4,737	8,415,302	74	$9,031	265	456	35
1898	5,882	9,074,311	75	9,781	244	627	27
1899	9,446	10,394,208	70	9,671	472	930	47
1900	6,988	9,633,647	35	57,910	733	602	39
1901	12,029	11,082,822	74	20,263	476	581	64
1902	15,448	13,220,005	123	19,357	771	690	44
1903	26,177	18,799,312	307	21,251	1,060	916	75
1904	14,682	24,521,115	228	28,112	1,151	898	69
1905	19,076	13,229,855	98	61,719	945	1,048	47
1906	15,976	10,981,611	375	54,494	1,317	1,141	68
1907 (o)	19,461	8,066,403	189	113,967	1,074	638	44
1908 (r)	....	8,844,129	102	63,582	3,396	2,653	81
1909 (s)	67,107	12,095,593	103	47,371	1,570	925	42

Year.	Sal-Ammoniac	Salt.	Silex.	Sodium Salts Except Chloride.	Sulphur.	Tin and Tinware.	Zinc.
1897	69	103,337	116	13,938	3,932	$1,274,108	542
1898	38	96,962	141	16,026	17,248	1,550,851	1,595
1899	53	88,397	179	20,742	11,121	1,372,813	852
1900	60	92,823	182	16,748	9,584	2,418,455	1,304
1901	76	103,402	162	18,631	10,827	2,339,109	931
1902	78	114,629	199	17,133	11,180	2,293,958	1,582
1903	114	112,188	159	18,887	11,077	2,712,168	1,209
1904	93	103,635	252	25,118	8,786	2,389,557	1,540
1905	143	97,723	405	26,219	10,633	2,791,757	1,721
1906	209	99,788	338	30,401	19,512	3,105,876	3,383
1907 (o)	130	73,156	542	25,068	11,725	2,473,572	2,761
1908 (r)	172	105,286	1,131	39,154	23,494	1,619,647	2,521
1909 (r)	162	119,660	417	33,787	19,981	2,984,065	2,993

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (*a*).

(In metric tons or dollars)

Year (*b*)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke	Copper (*e*).
1897	....	9,954	(*k*) 1,911	1,000,061	1,692	4,596
1898	1,118	16,718	(*k*) 1,527	981,963	3,275	6,319
1899	....	13,176	(*k*) 1,369	1,035,245	4,024	3,843
1900	6	16,483	(*k*) 334	1,489,139	12,558	6,274
1901	219	24,242	(*k*) 2,049	1,713,737	60,129	11,954
1902	13	30,011	(*k*) 672	1,649,278	52,873	13,789
1903	128	27,823	658	1,796,689	39,616	13,445
1904	87	31,444	2,103	1,494,106	61,750	20,279
1905	340	37,320	3,702	1,465,809	116,387	17,431
1906	388	40,367	1,640	1,651,203	50,004	20,082
1907 (*o*)	832	37,194	604	1,165,809	44,669	11,845
1908 (*r*)	693	53,543	1,585	1,702,673	50,343	25,824
1909 (*r*)	1	54,188	3,707	1,548,468	70,024	24,642

Year.	Gold. Quartz, Dust, etc.	Graphite	Grindstones	Gypsum Crude.	Iron Ore.	Lead (*p*).
1897	$ 2,804,101	78	$15,760	163,829	(*n*) 3,056	13,636
1898	3,387,953	348	18,785	163,660	(*n*) 1,975	19,944
1899	3,272,702	662	18,619	148,565	(*n*) 2,881	15,445
1900	14,148,543	1,742	22,196	211,792	(*n*) 5,012	8,998
1901	24,445,156	1,246	38,304	156,080	(*n*) 54,208	29,747
1902	19,668,015	783	21,878	243,629	(*n*) 478,503	13,890
1903	16,437 528	530	14,169	271,899	(*n*) 267,000	7,386
1904	18,715,539	269	12,676	247,741	(*n*) 214,309	7,329
1905	15,208,380	201	27,985	290,574	204,091	23,094
1906	12,991,916	180	15,793	367,203	134,270	6,158
1907 (*o*)	7,226,954	3	33,929	249,780	31,011	8,330
1908 (*r*)	8,817,041	167	28,726	340,235	23,863	12,650
1909 (*r*)	7,392,610	396	18,019	239,139	3,568	5,459

Year.	Manganese Ore.	Mica.	Nickel in Ore, Matte, etc.	Petroleum, Crude and Refined.	Pyrites.	Salt, *Bushels*.	Silver, *Kg.* (In Ore, Matte, etc.)
1897	74	217	3,415	1,831	14,219	4,702	127,440
1898	7	231	6,697	9,530	18,752	5,559	211,012
1899	24	538	6,546	4,268	11,707	5,209	137,400
1900	57	490	6,122	6,758	13,507	15,151	71,015
1901	33	444	4,327	19,942	22,146	56,461	125,110
1902	500	452	1,762	2,478	24,088	21,778	114,610
1903	137	632	4,098	413	16,762	7,959	100,861
1904	62	393	6,456	1,208	15,582	42,662	99,472
1905	84	461	5,431	6,441	20,473	5,663	112,076
1906	15	603	10,866	1,741	18,398	23,168	203,323
1907 (*o*)	84	631	7,355	(*q*) 3,167	20,148	5,113	274,178
1908 (*r*)	1	409	8,596	(*q*) 3,389	17,835	35,543	515,161
1909 (*r*)	3	243	8,895	(*q*) 61,624	23,087	198,087	733,248

(*a*) From Tables of the *Trade and Navigation of the Dominion of Canada*. (*b*) Fiscal year ending June 30. (*c*) Includes regulus and salts of antimony. (*d*) Asbestos in any form except crude, and all manufactures of. (*e*) Includes copper in ore, matte, regulus, etc. (*f*) Includes coal dust. (*g*) Coin, gold and silver, except U. S. silver coin. (*h*) Includes black lead, and crucibles (clay or graphite). (*i*) Includes Canadian lead ore refined in the United States (*k*) Calendar year. (*m*) Unclassified. (*n*) Includes chromic iron ore. (*o*) Returns for the 9 months of the fiscal year ending March 31. (*p*) Includes lead contained in ore, etc. (*q*) Gallons. (*r*) Fiscal year ending March 31. (*s*) Includes silver-nickel and German silver.

CHINA.

The official statistics of mineral imports and exports are summarized in the following tables:

MINERAL IMPORTS OF CHINA. (a)
(In metric tons.)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Petroleum, Gal.	Quick-silver.	Tin.	Tin-plate.	Zinc.	
									Spelter.	Sheet, etc.
1906	1,547	3,784	9,026	1.010	128,687,690	64	2,188	14,384	481	664
1907	1,223	8,948	8,047	60	161,284,355	53	3,309	17,950	172	548
1908..........	1,500	13,129	10,707	42	186,175,950	40	3,716	13,465	519	646

MINERAL EXPORTS OF CHINA. (a)
(In metric tons.)

Year.	Antimony.		Iron.		Lead.		Quick-silver	Tin.	Zinc. .	
	Ore.	Metal (b)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1906...............	3,624	3,829	111,460	34,305	....	5	18	4,126	7,678	73
1907...............	2,382	2,316	105,489	33,911	3,190	1	23	3,728	7,619	69
1908............	544	9,356	133,458	30,897	1,283	5	44	4,836	7,619	169

(a) From annual reports of the Imperial Chinese Maritime Customs. (b) Regulus and refined.

FRANCE.

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products:

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE. (*a*)
(In metric tons.)

Year.	Aluminum.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (*c*)	Cement.
		Ore.	Metal.						
1896	370	5,675	969	....	17,717	2,791	33,820	225,784	934,624
1897	470	4,685	1,033	....	17,982	3,209	41,740	233,328	976,813
1898	565	4,433	1,226	....	18,832	2,763	36,723	229,108	1,072,025
1899	763	7,392	1,499	2,600	22,100	4,058	48,215	258,449	1,144,271
1900	1,026	7,843	1,573	4,705	25,228	3,635	58,530	266,474	1,147,670
1901	1,200	9,867	1,786	7,491	20,391	4,145	76,620	249,655	1,127,206
1902	1,355	9,715	1,725	5,372	....	4,323	96,900	258,295	962,930
1903	1,570	12,380	2,748	6,658	....	5,731	133,890	243,295	898,393
1904	1,650	9,065	2,116	3,117	22,000	6,944	75,640	227,177	903 632
1905	1,905	12,543	2,396	3,627	20,000	5,504	103,207	188,403	922,531
1906	3,396	18,567	3,433	6,534	38,231	11,680	117,781	196,375	1,257,861
1907	4,700	24,000	3,950	7,900	33,000	11,150	158,000	177,000	1,253,546
1908	4,681	26,026	3,850	2,381	41,000	16,277	170,679	171,158	1,359,658

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1896	28,750,452	439,448	130,207	106	6,544	$217,308	264,187	1,429,550
1897	30,337,207	460,422	98,067	956	7,376	183,416	292,753	1,369,269
1898	31,826,127	529,977	104,265	382	7,834	177,435	303,531	1,449,384
1899	32,256,148	606,564	99,230	2,021	6,640	179,429	263,879	1,372,067
1900	32,721,562	682,736	95,630	3,031	6,446	134,904	192,916	1,405,845
1901	31,633,300	691,700	118,433	3,413	7,000	85,727	355,995	1,623,710
1902	29,365,047	632,423	109,941	828	6,300	(*b*)	219,487	1,572,687
1903	34,217,661	688,757	100,348	10,892	6,921	(*b*)	162,766	1,468,830
1904	33,502,394	665,572	95,716	2,756	6,900	(*b*)	106,173	1,481,303
1905	35,218,000	709,000	98,500	5,068	7,576	235,447	78,832	1,299,313
1906	33,458,000	738,000	92,469	2,547	5,770	511,665	79,568	1,297,861
1907	35,989,000	765,000	90,952	2,400	7,800	847,290	87,370	1,316,567
1908	36,633,000	751,000	79,759	766	7,935	960,666	92,898	1,326,131

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig.	Wrought Iron.	Wrought Steel.	Ore. (*d*)	Pig. (*e*)			
1896	4,069,390	2,339,537	828,758	916,817	19,042	8,232	2,224,847	31,318	28,237
1897	4,582,236	2,484,191	584,540	994,891	21,212	9,916	2,201,428	37,212	32,175
1898	4,731,394	2,525,100	766,000	1,174,000	23,342	10,920	2,339,850	31,935	38,929
1899	4,985,702	2,578,400	834,000	1,240,000	17,505	15,981	2,343,377	39,897	41,535
1900	4,676,740	2,714,298	672,172	1,226,537	24,276	15,210	2,377,110	28,992	41,103
1901	4,260,747	2,388,823	612,362	1,175,454	20,644	21,000	2,443,062	22,304	33,286
1902	5,003,782	2,405,000	639,600	1,245,800	22,634	19,000	4,796,807	12,536	34,504
1903	6,219,541	2,840,517	598,910	1,305,709	23,080	23,258	4,727,543	11,583	35,031
1904	7,022,841	2,999,787	554,632	1,482,708	14,173	18,800	4,583,522	11,254	37,409
1905	7,395,409	3,077,000	670,000	1,442,000	12,118	24,100	3,694,725	6,751	33,468
1906	8,481,423	3,314,100	747,900	1,683,500	11,795	25,614	3,869,772	11,189	32,407
1907	10,008,000	3,590,000	579,900	1,860,000	18,000	24,800	2,438,409	18,200	30,480
1908	10,057,145	3,400,700	560,200	1,851,900	13,403	26,112	2,535,833	15,865	30,522

Year.	Mineral Paints (Ochers).	Nickel.	Phosphate Rock.	Pyrites.	Salt.	Silver. *Kg.*	Sulphur Ore. (*g*)	Zinc. Ore.	Zinc. Metal.
1896....	27,499	1,545	582,667	282,064	1,042,614	....	9,720	81,346	35,585
1897....	32,299	1,245	535,390	303,488	948,003	....	10,723	83,044	38,067
1898....	33,780	1,540	568,558	310,972	999,283	....	9,818	85,550	37,155
1899....	32,750	1,740	645,868	318,832	1,193,532	....	11,744	84,813	39,274
1900....	33,080	1,700	587,919	305,073	1,088,634	....	11,551	67,059	36,305
1901....	35,704	1,800	535,676	307,447	910,000	....	7,000	61,539	37,600
1902....	34,770	1,600	543,900	318,235	863,927	....	8,021	57,982	36,300
1903....	34,042	1,500	475,783	322,118	967,531	....	7,375	66,922	37,416
1904....	34,945	1,500	423,521	271,544	1,153,754	....	5,447	52,842	41,600
1905....	37,800	1,800	476,720	267,114	1,130,088	....	4,637	62,150	43,200
1906....	35,550	1,750	469,408	265,261	1,335,420	50,058	2,713	53,466	46,536
1907....	32,856	1,500	432,237	283,000	1,226,000	47,009	2,000	44,000	47,900
1908....	33,060	1,800	485,607	284,717	1,100,000	61,184	2,189	52,611	47,880

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur.

MINERAL PRODUCTION OF ALGERIA. (*a*)

(In metric tons.)

Year.	Antimony Ore.	Copper Ore.	Gypsum. Crude.	Gypsum. Plaster.	Iron Ore.	Lead-silver Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
1896..	658	427	300	29,870	374,476	117	....	900	165,738	19,658	17,587
1897..	781	289	350	29,120	441,467	145	....	364	228,141	23,222	32,269
1898..	138	488	150	29,750	473,569	120	....	219	269,500	21,300	29,800
1899..	200	472	200	31,800	550,921	389	....	217	324,983	17,378	42,970
1900..	93	....	500	37,100	174,000	222	....	228	319,422	18,325	30,281
1901..	....	7,267	600	34,740	161,303	1,614	....	294	265,000	18,518	26,913
1902..	39	1,955	600	35,500	525,012	26	....	150	305,174	27,263	33,139
1903..	490	100	300	33,000	588,893	499	....	67	320,834	26,329	43,313
1904..	160	1,804	350	38,420	468,737	511	....	121	343,317	18,563	47,192
1905..	....	1,784	.. ...	34,743	568,609	7,470	....	270	334,784	26,986	67,922
1906..	50	2,786	....	27,950	779,826	11,246	....	216	333,531	22,615	74,351
1907..	799	16,259	....	26,400	973,445	15,264	590	328	373,763	20,390	71,048
1908..	190	3,3 30	....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,399

(*a*) From *Statistique de l'Industrie Minérale.*

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1897..	3,949	3,200	2,200	26,464	1903..	21,437	8,292	10	77,360
1898..	7,712	2,373	*Nil.*	74,614	1904..	42,197	8,964	*Nil.*	98,655
1899..	12,634	3,294	6,349	103,908	1905..	51,374	7,920	*Nil.*	125,289
1900..	10,474	2,438	2	100,319	1906..	84,241	2,600	207	118,890
1901..	17,451	3,123	6,349	132,814	1907..	31,552	29,800	437	119,000
1902..	10,281	7,512	3,720	129,653	1908..	15,800	2,360	(*b*) 10	108,000

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) From *Le Bulletin du Commerce* Nouméa.

MINERAL PRODUCTION OF TUNIS. (*a*)

(In metric tons.)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1897..	8,100	2,123	(*b*)	11,830	1903..	18,846	12,752	352,088	21,262
1898..	7,300	2,375	(*b*)	21,477	1904..	23,600	16,800	455,197	27,200
1899..	8,850	2,263	70,000	20,079	1905..	54,900	15,200	522,000	37,100
1900..	9,160	6,864	178,000	16,596	1906..	62,600	14,800	796,000	32,400
1901..	16,900	8,158	172,000	17,879	1907..	78,200	18,600	1,069,000	22,800
1902..	21,600	12,892	264,930	18,400	1908..	149,600	37,500	1,300,500	26,500

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported.

MINERAL IMPORTS OF FRANCE. (a)
(In metric tons or dollars. 5 f. = $1.)

Year.	Alum.	Bitumen. (f)	Borax.	Bromides.	Cement.	Coal and Coke.	Copper.		Copper.	
							Ore.	Ingot and Mfrcs.	Sulphate.	Oxide.
1895....	109	43,975	442	12	13,441	10,261,069	10,450	38,196	24,404	24
1896....	41	30,954	255	13	14,395	10,180,449	8,584	46,830	33,803	22
1897....	54	29,931	264	18	15,141	10,457,255	11,960	54,460	30,132	29
1898....	27	20,385	139	30	11,290	10,445,090	8,779	52,976	30,897	52
1899....	34	30,770	123	46	13,640	11,896,030	8,517	58,419	21,733	36
1900....	23	39,598	111	10	13,612	14,601,981	9,766	61,638	22,820	84
1901....	39	28,888	128	3	16,232	13,925,623	13,383	47,035	15,313	162
1902....	36	26,053	141	3	15,720	13,137,720	17,862	54,484	22,273	111
1903....	138	27,573	312	9	21,152	14,029,687	9,796	59,126	25,428	129
1904....	370	17,178	3,113	17	21,702	13,936,475	9,942	69,183	30,856	142
1905....	63	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	105	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	......	31,700	....	....	24,839	18,706,000	12,063	76,282	....	....
1908 (k).	......	48,000	....	....	31,550	18,563,000	15,300	86,985	....	....

Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfres. of.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap and Mfres.
1895....	....	1,651,369	36,247	66,240	3,882	855	....	5,032	1,077	66,241
1896....	....	1,862,043	18,323	48,423	3,086	897	38,703	5,569	892	79,752
1897....	....	2,137,860	35,633	60,804	1,353	1,125	42,384	13,981	1,327	86,589
1898....	....	2,032,240	(b)	47,325	896	1,021	40,352	14,377	1,376	74,902
1899....	....	1,950,665	(b)	64,178	1,698	1,037	36,904	12,637	2,029	67,149
1900....	....	2,119,003	149,755	118,152	1,589	1,022	39,842	19,772	1,739	70,857
1901....	....	1,662,875	61,085	77,742	45	1,001	41,972	15,430	1,789	59,051
1902....	....	1,563,334	38,521	60,697	17	1,051	41,165	13,121	2,223	58,694
1903....	....	1,832,820	121,726	119,799	36	1,207	47,534	20,172	2,040	75,416
1904....	....	1,738,514	135,252	125,709	319	1,151	50,465	25,731	2,221	76,198
1905....	....	2,151,954	122,102	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	....	2,015,550	156,618	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	154,031	336,337	....	....	53,447	42,342	....	53,359
1908 (k).	1,500	1,454,000	168,810	373,624	....	....	58,909	40,700	....	70,824

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum. Kg.	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (h)
1895....	1,047	41,400	10,303	252	258,700	139,600	926	3,524	2,875
1896....	2,033	61,600	15,756	425	272,693	256,888	2,117	11,499	2,838
1897....	1,713	85,500	17,441	316	288,671	313,608	1,069	11,630	2,852
1898....	1,288	100,243	24,935	330	291,961	336,842	505	10,929	2,890
1899....	1,887	106,630	28,620	286	306,078	242,021	817	13,335	3,147
1900....	1,215	120,790	17,687	299	302,482	283,921	2,398	13,524	3,293
1901....	1,400	94,365	39,497	252	225,962	275,285	1,857	13,299	2,784
1902....	2,130	85,629	58,374	301	148,170	302,898	2,940	10,802	2,861
1903....	919	109,930	13,933	427	(g)476,230	343,012	3,764	12,275	2,760
1904....	1,679	105,652	20,698	313	(g)435,730	419,720	5,650	14,734	2,618
1905....	406	140,871	49,698	632	(g)512,727	447,738	4,023	21,819	2,619
1906....	593	127,235	44,960	480	(g)213,462	533,213	5,708	26,523	3,024
1907....	....	192,448	45,892	979	(g)311,000	636,549	4,373	....	....
1908 (k).	....	170,500	42,200	1,281	(g)300,000	767,424	3,955	....	....

Year.	Potassium. (*Cont'd.*)		Pyrites.	Quicksilver.		Sal-Ammoniac.	Salt.	Sodium.	
	Nitrate.	Carbonate		Ore.	Metal.			Hydrate.	Nitrate.
1895..........	775	796	67,930	23	178	9,923	17,528	1,021	8,624,200
1896..........	2,614	1,526	45,788	25	234	15,256	17,191	1,109	9,025,400
1897..........	1,309	1,769	69,470	24	248	27,454	32,917	1,378	8,105,400
1898..........	1,008	2,418	71,569	19	221	20,426	35,863	1,772	8,026,400
1899..........	1,015	2,779	109,696	21	276	12,210	37,970	1,494	9,341,600
1900..........	1,928	2,768	156,825	22	161	15,205	32,045	1,062	11,995,820
1901..........	757	2,520	205,617	23	205	9,268	32,347	869	10,526,400
1902..........	1,547	1,539	170,783	24	224	15,446	32,505	643	9,372,600
1903..........	1,530	3,019	205,322	20	220	12,462	48,556	781	10,810,775
1904..........	2,117	3,781	230,097	22	208	13,744	46,232	1,068	9,074,859
1905..........	1,022	3,542	271,684	....	228	11,639	45,241	860	11,336,752
1906..........	684	2,206	349,514	....	242	18,146	38,361	614	13,678,848
1907..........	....	....	355,300	....	216	....	30,000	....	....
1908 (*k*).......	....	....	348,300	....	180	....	33,000	....	....

Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1895............................	110,989	3,461	150,758	104	7,691	41,622	25,652
1896............................	111,515	3,995	185,602	7	8,400	50,899	33,459
1897............................	136,118	3,147	195,853	149	7,642	58,074	31,211
1898............................	130,289	4,666	178,569	357	9,247	60,481	32,342
1899............................	120,062	4,583	171,631	486	6,907	78,192	25,516
1900............................	133,531	4,254	143,437	512	7,324	66,178	33,144
1901............................	101,301	5,386	165,361	365	7,314	74,553	29,812
1902............................	85,839	7,793	116,093	748	8,575	69,451	36,564
1903............................	109,594	13,241	89,229	1,808	9,873	67,258	39,305
1904............................	148,547	11,212	72,921	1,344	9,352	88,083	35,737
1905............................	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906............................	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907............................	106,050	....	....	961	7,693	114,699	33,503
1908 (*k*).........................	195,000	....	....	1,000	8,482	137,900	40,312

MINERAL AND METALLURGICAL EXPORTS OF FRANCE. (*a*)
(In metric tons.)

Year.	Aluminum.	Antimony.		Arsenic.	Cement.	Coal.	Copper		Gold. *Kg.* (*d*)
		Ore.	Metal.				Ore. (*c*)	Metal.	
1895..................	110	832	68	....	(*b*)	(*b*)	1,772	8,829	1,353
1896..................	793	736	74	....	242,247	1,044,820	1,261	10,494	2,193
1897..................	224	623	61	....	244,504	1,142,195	2,000	12,667	3,335
1898..................	192	616	101	....	241,150	1,320,616	1,783	14,350	1,812
1899..................	256	304	255	....	244,480	1,229,090	2,078	17,949	2,622
1900..................	324	154	336	....	232,577	1,201,210	9,197	16,791	883
1901..................	307	645	741	....	242,010	908,583	16,066	14,776	1,369
1902..................	748	595	666	....	210,590	910,760	20,489	14,423	1,517
1903..................	666	904	1,358	....	233,835	2,238,735	12,487	11,403	3,139
1904..................	664	1,191	720	....	260,686	2,384,928	14,258	12,663	1,537
1905..................	928	981	815	....	275,503	(*i*) 3,348,010	13,260	13,800	5,740
1906..................	1,522	3,541	871	....	329,879	(*i*) 1,448,000	8,056	6,130	11,727
1907..................	1,118	3,460	1,270	....	366,624	(*i*) 1,224,000	4,151	18,630	6,289
1908 (*k*)...............	1,332	3,300	2,129	8,600	342,131	(*i*) 1,117,000	3,600	17,845	4,455

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1895	236,923	150,540	....	29,074	8,670	8,037	16,193
1896	238,430	195,212	24,721	44,795	8,597	10,856	10,913
1897	299,589	108,645	39,894	45,809	12,007	10,364	19,464
1898	236,169	162,991	27,424	47,278	10,216	3,663	12,229
1899	291,346	153,792	29,112	33,584	3,909	1,163	12,289
1900	371,799	114,361	18,763	19,535	2,345	958	8,392
1901	258,925	96,463	25,220	56,347	3,490	718	5,289
1902	422,677	213,081	23,828	121,932	2,414	648	1,948
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1.860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908 (*k*)	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000

Year.	Nickel Refined.	Phosphate Rock.	Plaster.	Pyrites.	Silver. *Kg.* (*e*)	Tin (Metal).	Zinc.	
							Ore.	Spelter. Sheets and Scrap.
1895	408	....	....	37,968	13,567	650	61,291	5,849
1896	490	48,719	89,952	44,232	9,849	744	62,415	10,485
1897	498	69,188	107,823	54,367	5,374	651	79,909	10,977
1898	526	93,742	106,790	60,406	1,886	587	60,664	16,995
1899	280	70,517	112,520	53,395	....	666	76,104	14,958
1900	599	89,135	108,387	64,530	15,470	716	54,663	12,712
1901	1,031	81,405	101,063	52,952	16,745	438	42,995	15,022
1902	397	62,375	110,270	63,920	17,184	654	47,724	16,158
1903	720	72,252	131,245	119,173	43,690	1,994	62,731	12,657
1904	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908 (*k*)	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589

(*a*) From *L'Economiste Français* (representing the *Commerce Spécial*) except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation.* (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry and crude platinum. (*e*) Silver in sheets, leaves, wire and jewelry. (*f*) Includes bitumen, bituminous schist and sands and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke. (*k*) From *Statisque de l'Industrie Minérale.*

GERMANY.

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar.

MINERAL PRODUCTION OF GERMANY. (*a*)

Year.	Alum.	Aluminum Sulphate.	Arsenic.		Asphaltum.	Boracite.	Cadmium. *Kg.*	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1897	2,995	37,053	3,777	2,989	61,645	198	15,531	91,054,982	29,419,503
1898	4,069	35,366	3,527	2,679	67,649	230	14,943	96,309,652	31,648,898
1899	3,358	37,693	3,834	2,423	74,770	183	13,608	101,639,753	34,204,666
1900	4,355	44,372	4,379	2,415	89,685	232	13,553	109,290,237	40,498,019
1901	4,145	46,807	4,035	2,549	90,193	184	13,144	108,539,444	44,479,970
1902	4,108	47,905	3,959	2,828	88,374	196	....	107,473,933	43,126,281
1903	3,934	49,727	4,369	2,768	87,454	159	16,565	116,637,765	45,819,488
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	....	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	....	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	....	148,899,745	68,533,743

Year.	Cobalt, Nickel and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (*b*)	Ingots.	Sulphate.		
1897	3,355	700,619	315	29,408	5,549	$1,848,114	3,861
1898	3,157	702,781	62	30,695	4,352	1,891,974	4,593
1899	1,270	733,619	95	34,634	5,142	1,731,153	5,196
1900	4,495	747,749	4,207	30,929	5,076	2,030,200	9,248
1901	10,479	777,339	365	31,317	5,192	1,830,835	4,435
1902	12,433	761,921	447	30,578	4,997	1,770,361	5,023
1903	14,607	772,695	583	31,214	5,200	1,709,223	3,720
1904	14,016	798,214	641	30,264	6,584	1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	....	798,618	2,242	31,126	6,211	3,366,986	6,774

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (*c*)	Wrought iron and Steel.	Sulphate. (*d*)	Ore.	Pig.	Litharge
1897	15,465,980	6,881,466	6,248,141	10,351	150,178	118,881	3,441
1898	15,901,263	7,312,766	6,941,278	10,422	149,311	132,742	3,857
1899	17,989,635	8,153,133	7,532,524	10,931	144,370	129,225	3,562
1900	18,964,294	8,520,540	7,377,275	10,913	148,257	121,513	3,088
1901	16,570,182	7,880,087	7,033,438	11,148	153,341	123,098	4,101
1902	17,963,591	8,529,900	8,317,231	....	167,855	140,331	4,197
1903	21,230,650	10,017,901	9,226,898	12,243	165,991	145,319	4,428
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
190	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,625,575	11,852,783	21,838	159,852	167,920	3,059

Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (*f*)	Sulphate.	Potassium and Magnesium Sulphate.	Other than Kainite.
1897	18,014	35,072	46,427	23,303	168,001	992,389	13,774	7,812	953,798
1898	19,819	30,295	43,354	25,989	191,347	1,103,643	18,853	13,982	1,105,212
1899	21,370	39,540	61,329	27,027	207,506	1,108,159	26,103	9,765	1,384,972
1900	19,397	48,591	59,204	50,375	271,512	1,227,873	30,853	15,368	1,822,758
1901	21,018	46,714	56,691	44,095	294,666	1,498,569	37,394	15,612	2,036,325
1902	19,658	39,262	49,812	49,725	267,512	1,322,623	28,278	18,147	1,962,384
1903	22,990	37,844	47,994	62,680	280,248	1,557,243	36,674	23,631	2,073,720
1904	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908	29,775	42,977	67.692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909	31,526	53,812	77,177	143,244	629,393	3,071,619	68,539	38,722	3,969,554

Year	Pyrites.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1897	133,302	763,412	543,272	9,708	448,068	68,822	2,317	702,445
1898	136,849	807,792	565,683	14,702	480,578	69,111	1,954	754,151
1899	144,623	861,123	571,058	13,506	467,590	79,062	1,663	813,141
1900	169,447	926,563	587,464	12,593	415,735	90,468	1,445	829,376
1901	157,433	985,050	578,751	11,577	403,796	76,066	963	835,000
1902	165,225	1,010,412	572,846	11,724	430,610	90,742	....	894,400
1903	170,867	1,095,541	598,394	11,467	396,253	83,087	219	928,190
1904	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908	219,456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909	198,688	1,370 668	647,939	7,510	400,562	71,813	1,185	1,434,709

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore	Spelter.	Sulphate.
1897	55	929	....	38	663,850	150,739	5,488
1898	51	993	....	50	641,706	154,867	6,104
1899	72	1,481	....	50	664,536	153,155	7,117
1900	80	2,031	(*g*) 143	43	639,215	155,790	6,027
1901	82	1,464	(*g*) 135	43	647,496	166,283	5,552
1902	104	2,779	....	31	702,504	174,927	....
1903	110	3,065	1,064	35	682,853	182,548	5,994
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	....	6,597	987	....	704,590	205,691	6,092
1907	....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	....	8,994	3,247	....	723,565	219,766	5,574

(*a*) From the *Vierteljahrsheite zur Statistik des Deutschen Reichs.* Where gold is reported 1 mark=$0.238. (*b*) Includes black copper. (*c*) Includes ferromanganese and spiegeleisen. (*d*) Contains a small quantity of copper and iron sulphate mixed. (*f*) Compound of potassium chloride and magnesium sulphate. (*g*) Includes nickel sulphate.

MINERAL PRODUCTION OF BADEN. (a)
(In metric tons and dollars; 4 marks=$1.)

Year.	Aluminum Sulphate.	Barytes.	Coal.	Gypsum.	Manufacturers of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1896	1,824	130	4,001	32,801	31,356	3,418	1,118
1897	1,824	400	4,752	40,702	36,235	3,875	1,167
1898	2,051	1,100	4,133	28,037	39,988	3,875	1,167
1899	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901	2,260	3 991	3,650	28,183	40,100	8,739	1,158
1902	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903	2,498	8,857	1,990	29,423	45,233	7,666	863
1904	2,392	9,078	1,485	26,984	64,320	7,687	783
1905	2,581	11,094	668	28,823	74,128	8,053	842
1906	2,583	11,984	1,000	25,643	81,387	11,068	466
1907	2,644	9,303	2,075	29,153	98,430	10,818	533
1908	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909	2 329	(c)15,186	2,356	36,621	83,458	11,643	484

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1896	(b)	29,227	14,226	9	(b)
1897	(b)	31,445	13,365	9	(b)
1898	(b)	31,445	13,365	6	(b)
1899	(b)	31,197	13,660	12	357
1900	67	32,699	15,938	9	3,004
1901	369	32,835	17,081	8	2,870
1902	450	32,192	19,265	11	2,958
1903	350	32,383	19,755	11	3,171
1904	265	32,148	35,517	12	5,063
1905	264	31,393	40,781	12	4,046
1906	246	31,288	38,655	15	1,466
1907	278	32,078	42,831	25	2,198
1908	329	33,993	41,455	13	2,793
1909	372	34,040	42,219	14	3,253

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA. (a)
(In metric tons; 4 marks=$1.)

Year.	Barytes.	Kaolin.	Coal.	Coal. (Lignite).	Copperas and other Sulphate.	Emery.	Feldspar.	Fluorspar.	Graphite.
1896	3,397	19,080	900,080	35,934	601	249	1,315	5,218	5,248
1897	3,365	24,086	917,022	39,043	981	217	1,689	4,904	3,861
1898	4,339	29,196	964,611	38,663	886	280	1,949	4,440	4,593
1899	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902	8,034	92,073	1,233,568	27,337	691	225	447	5,460	5,023
1903	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908	17,195	68,551	707,867	1,414,966	910	245	5,859	5,480	4,844
1909	17,920	187,312	759,351	1,480,053	1,094	305	3,151	5,580	6,774

Year.	Gypsum.	Iron. Ore.	Bar.	Cast, 1st Fusion	Cast, 2d Fusion	Pig.	Steel.	Litho-graphic Limestone.
1896	28,799	161,279	53,573	114	71,006	79,621	101,954	10,868
1897	26,153	172,699	58,200	138	78,008	83,418	115,530	13,941
1898	25,688	171,987	58,342	97	84,227	84,144	120,623	12,029
1899	29,727	181,981	61,415	(b)	92,459	83,821	134,007	11,962
1900	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902	31,701	157,375	38,429	56	81,874	83,123	115,354	....
1903	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904	22,766	180,342	37,780	40	108,025	92,200	125,483	13,836
1905	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906	50,763	203,596	38,508	....	122,115	97,812	150,129	....
1907	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11 590
1908	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420

Year.	Marl. (For Cement).	Mineral Paint and Chalk.	Pyrites.	Rock Salt	Soap-stone.	Sodium Sulphate.	Sulphuric Acid.
1896	94,481	8,667	1,997	708	3,051	663	7,064
1897	97,831	8,673	2,211	1,161	2,464	2,318	7,041
1898	110,757	8,748	2,304	736	1,912	2,332	103,385
1899	220,716	9,287	2,516	802	2,197	1,570	123,273
1900	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902	178,301	13,947	2,635	832	....	....	....
1903	200,407	19,486	2,324	879	1,866	....	....
1904	170,698	19,107	3,427	1,139	1,709	....	....
1905	231,310	18,285	3,301	911	1,872	....	....
1906	230,271	22,304	3,918	1,053	....	....	....
1907	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909	276,974	21,692	2,952	1,860	2,329	1,265	178,371

(*a*) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (*b*) Not reported.

MINERAL PRODUCTION OF PRUSSIA. (*a*)

(Metric tons; 4 marks=$1.)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1897	129	1,552	1,924	3,377	11,466	185	15,531	84,253,393
1898	107	2,612	1,624	3,298	12,822	216	14,943	89,593,528
1899	145	3,003	1,469	3,265	16,458	171	13,608	94,740,829
1900	103	3,025	1,585	3,531	23,891	217	13,533	101,966,158
1901	611	2,404	1,446	3,050	26,450	164	13,144	101,203,807
1902	219	3,542	1,514	2,909	28,035	172	12,625	100.115,315
1903	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904	106	2,774	1,573	3,527	26,348	115	25,245	112,755,621
1905	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907	154	3,515	1,591	4,224	39,243	90	32,949	134,044,080
1908	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194

Year.	Coal. (Lignite.)	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1897	24,222,911	121	51	25,997	225	690,338	274
1898	26,035,814	34	44	27,216	120	691,866	62
1899	28,418,598	17	46	20,902	154	722,884	95
1900	34,007,542	4	52	27,156	113	747,601	4,207
1901	37,491,412	36	66	28,422	78	765,241	281
1902	36,228,285	76	74	27,893	119	751,496	346
1903	38,462,766	65	87	28,386	110	761,188	488
1904	41,153,576	41	85	27,450	95	782,049	601
1905	44,148,751	22	99	28,874	102	769,381	1,052
1906	47,912,721	7	98	29,166	94	755,812	525
1907	52,660,597	*Nil.*	109	28,945	64	755,203	499
1908	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909	56,029,554	*Nil.*	93	28,523	55	788,819	1,935

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1897	2,689	2,248	1,087.1	4,892,059	4,183,536	9,064	108,880
1898	1,701	2,061	1,036.3	5,176,943	4,020,809	9,144	119,346
1899	1,586	1,793	1,016.4	5,644,614	4,295,575	10,186	116,995
1900	1,660	1,511	1,076.6	5,781,892	4,268,069	10,225	112,738
1901	1,951	1,952	1,087.1	5,315,628	3,831,670	10,239	113,939
1902	1,937	761	1,138.0	5,633,089	3,362,887	11,214	127,283
1903	2,254	421	949.5	6,614,768	3,786,743	11,086	133,405
1904	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907	2,129	263	771.0	8,626,300	5,077,773	13,014	132,366
1908	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
1909	2,500	395	588.2	8,410,824	4,389,950	18,295	156,534

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1897	133,158	1,999	45,254	898	204	167	2,400
1898	133,637	2,360	42,232	1,108	79	127	2,376
1899	128,942	2,482	60,379	1,115	91	123	2,770
1900	133,483	2,366	58,016	1,376	3,896	115	2,850
1901	139,285	2,885	55,866	1,660	9,922	120	2,800
1902	152,282	2,516	48,882	1,605	11,816	159	2,780
1903	151,746	2,710	47,110	1,945	14,058	173	2,850
1904	150,328	2,517	52,092	2,333	13,518	207	3,200
1905	138.928	2,272	51,048	2,631	10,432	220	3,170
1906	127,322	2,744	51,881	2,648	7,472	187	3,635
1907	133,528	2,959	72,442	2,093	7,557	189	3,707
1908	141,316	4,190	67,241	2,622	8,238	181	3,183
1909	142,698	2,365	76,741	3,186	10,095	163	3,435

Year.	Petroleum.	Potassium Salts.		Pyrites.	Quick-silver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1897	2,600	716,348	640,236	121,766	4,867	274,888	310,755
1898	2,545	744,240	718,957	128,077	4,717	286,051	329,959
1899	3,405	744,657	941,055	134,564	2,611	288,588	331,943
1900	27,731	857,271	1,264,993	159,186	1,711	287,005	354,603
1901	24,098	1,068,237	1,131,703	148,457	1,713	290,869	353,557
1902	29,520	943,450	1,344,541	155,410	1,828	291,296	359,006
1903	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909	113,518	2,431,401	2,436,319	188,015	5,213	344,685	491,071

Year.	Silver *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sul-phate.
1897	289,960	6	2,091	484,289	912	663,739	150,739	3,583
1898	291,969	43	1,757	531,838	979	641,671	154,643	4,158
1899	293,858	7	1,419	573,733	1,461	663,763	152,987	4,864
1900	266,577	1	1,207	593,109	2,010	636,068	155,760	3,742
1901	246,286	6	772	609,041	1,443	644,504	166,223	3,369
1902	273,901	17	250	677,798	2,753	699,392	174,892	3,381
1903	255,722	13	16	724,784	3,042	679,320	182,472	3,586
1904	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908	274,154	7	706	997,931	6,330	703,394	212,991	3,223
1909	271,779	2	1,096	1.006,787	8,943	720,139	214,551	3,434

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*

MINERAL IMPORTS OF GERMANY. (a)

Year.	Aluminum, Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (b)
1897	....	33,113	....	....	....	....	....	....	....
1898	....	30,254	....	....	....	....	....	....	....
1899	....	28,868	....	....	....	61,534	....	....	....
1900	943	23,105	1,461	1,291	6,850	80,765	48,986	3,062	7,282
1901	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,764
1902	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909	8,696	58,132	2,719	3,017	11,928	1,209	98,378	1,907	14,560

Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (d), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Anthracite Cannel.	Lignitic.	
1897	....	....	....	42,364	....	....	6,072,029	8,111,076	435,161
1898	....	....	....	53,519	....	....	5,820,332	8,450,149	332,579
1899	....	....	....	63,388	....	....	6,220,489	8,616,751	462,577
1900	2,403	29,383	7,703	79,303	(d) 63,929	18,728	7,384,049	7,960,313	512,690
1901	2,537	24,113	9,526	87,262	(d) 29,611	18,222	6,297,389	8,108,943	400,197
1902	2,057	26,698	11,287	52,018	(d) 26,408	10,152	6,425,658	7,882,010	382,488
1903	2,567	22,316	14,081	49,870	(d) 33,362	13,919	6,766,513	7,962,123	432,819
1904	2,603	27,849	14,840	60,188	(d) 32,581	18,132	7,299,042	7,669,099	550,302
1905	2,802	39,137	17,256	148,118	(d) 35,529	11,998	9,399,693	7,945,261	713,619
1906	3,044	43,117	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012

Year.	Peat. and Peat Coke.	Briquettes	Cobalt and Nickel Ore.	Copper.				Copperas.	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1897	....	....	....	....	67,573	400	....	....	....
1898	....	....	....	....	73,291	450	....	....	....
1899	....	....	....	....	70,091	610	....	....	....
1900	19,807	137,153	13,032	10,930	83,503	906	2,369	752	1,460
1901	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904	9,071	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(k)
1907	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(k)
1908	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(k)
1909	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(k)

Year.	Gold. Silver and Platinum Ores.	Graphite.	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1897	8,927	17,366	....	164	3,185,644	423,127	....	35,092	696
1898	7,841	20,269	....	216	3,516,577	384,561	....	47,497	822
1899	7,597	23,400	....	191	4,165,372	612,652	....	55,635	703
1900	9,153	22,495	7,571	236	4,107,840	726,712	51,338	70,252	698
1901	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890

Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products.		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1897	....	86,911	....	1,390	....	946,344	83,957	....
1898	....	130,711	....	1,467	....	954,646	97,028	....
1899	....	196,825	....	1,391	....	963,943	106,624	....
1900	13,920	204,420	12,107	1,712	3,457	989,361	124,505	381
1901	8,897	222,010	9,403	1,947	1,981	985,904	118,999	313
1902	12,237	204,647	7,719	1,458	1,585	1,006,829	125,667	350
1903	14,958	223,709	9,888	1,507	1,663	1,067,697	147,837	222
1904	15,877	255,760	10,494	1,712	1,300	1,076,324	142,929	220
1905	19,459	262,311	11,473	1,955	1,114	1,070,252	143,926	198
1906	25.527	331,171	3,960	3,478	1,303	984,134	180,989	208
1907	30,857	393,327	2,166	2,182	1,653	1,115,205	226,609	165
1908	28,305	334,133	1,635	3,058	1,447	1,123,632	216,887	141
1909	29,994	384,445	2,036	3,745	1,447	1,085,839	216,987	179

Year.	Phosphate Rock.	Potassium Salts.							Pumice-stone. (*g*)	Pyrites.
		Chloride.	Cyanide. (*f*)	Iodide	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1897	289,234	715	7	18	2,889	1,734	....	912	....	356,869
1898	270,988	422	2	16	1,895	1,486	....	999	....	376,817
1899	407,457	443	3	9	1,785	1,737	....	533	....	437,732
1900	320,138	484	2	10	2,047	1,522	283	856	2,154	457,679
1901	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902	430,043	261	3	10	1,889	2,112	42	266	2,070	482,095
1903	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,526
1908	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (*n*)
				Soda, Calcined.	Nitrate (Chile Saltpeter.)	Sulphate and Sulphite.	
1897	(*e*)	(*e*)	670,224	916	465.493	....	....
1898	560	21,957	685,118	524	425,054	....	....
1899	572	22,040	892,764	515	526,944	....	....
1900	555	21,738	974,947	373	484,544	9,450	8,701
1901	651	23,901	733,931	178	529,568	7,921	19,739
1902	648	26,404	831,282	121	467,024	7,308	34,035
1903	674	20,118	877,394	114	467,130	6,058	24,183
1904	691	18,743	846,738	179	506,172	9,598	18,055
1905	729	20,726	888,665	143	540,916	4,752	13,720
1906	698	16,997	813,388	189	593,218	7,405	5,212
1907	831	23,109	568,046	257	591,131	10,446	5,595
1908	648	24,975	562,853	293	604,457	4,404	4,211
1909	723	19,509	492,771	181	665,450	9,023	4,277

Year.	Sulphur.	Sulphuric Acid	Superphosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc-white, Zinc-gray, Lithophon.
1897	25,305	....	....	12,395	24,735	19,734	130	3,532
1898	30,269	....	....	14,623	48,050	24,116	53	3,653
1899	31,196	....	....	12,253	57,880	23,691	95	4,226
1900	40,689	20,634	72,062	12,454	68,982	24,263	145	4,884
1901	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907	44,700	59.753	62.877	12,814	184,703	28.459	134	10,189
1908	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909	42,941	74.384	80,512	13,537	20,110	44,514	99	7,002

MINERAL EXPORTS OF GERMANY. (*a*)

Year.	Aluminum, Refined and Crude.	Aluminum, Nickel Wares, etc.	Aluminum Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1897	....	1,899	....	....	2,623	....	....	....
1898	....	2,045	....	....	4,083	....	....	....
1899	....	2,312	....	....	1,553	....	....	....
1900	269	2,398	29,372	3,196	2,431	284	131	786
1901	282	2,270	31,171	3,196	9,842	283	76	826
1902	410	2,608	34,005	3,351	5,744	410	105	954
1903	353	2,865	28,513	2,778	5,592	427	83	873
1904	407	3,077	29,311	3,106	10,696	486	250	964
1905	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906	1,111	1,321	25,937	3,555	37,288	548	221	997
1907	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908	590	642	22,376	1,161	73,186	588	146	1,030
1909	469	1,273	28,623	1,189	58,722	577	169	1,090

Year.	Arsenic.		Asbestos.	Barytes. (*b*)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1897	....	....	....	....	....	....	....	....	....
1898	....	....	....	....	....	....	....	....	....
1899	....	....	....	....	....	....	....	....	....
1900	14	1,573	496	59,012	5,927	2,717	44	2,894	191
1901	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906	....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907	(*m*)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908	(m)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909	(*m*)54	1,003	1,764	90,615	5,340	4,888	1,116	2,755	206

Year.	Bromine Salts.	Calcium.		Cement.	Chalk. Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous Anthracite and Cannel	Lignitic.
1897	....	....	....	524,557	....	....	....	12,389,907	19,112
1898	....	....	....	551,744	....	....	....	13,989,223	22.155
1899	....	....	....	580,255	....	....	....	13,943,174	20,925
1900	255	224	1,315	600,386	(*d*) 11,860	427	1,192	15,275,805	52,795
1901	249	275	888	560,612	(*d*) 14,134	581	1,299	15,266,267	21,718
1902	357	126	1,346	699,378	(*d*) 8,475	846	1,758	16,101.141	21,766
1903	435	335	1,831	742,381	(*d*) 12,211	37	1,921	17,389,934	22,499
1904	411	608	2,381	635.248	(*d*) 11,359	47	2,432	17,996,726	22,135
1905	634	709	2,831	675,664	(*d*) 13,081	43	2,507	18,156,998	20,118
1906	643	545	(*l*)	736,579	4,287	(*h*) 36	2,942	19,550,964	18,759
1907	655	918	(*l*)	692.982	2,919	(*h*) 149	3,110	20.056,503	22,065
1908	506	844	(*l*)	528,847	2.108	(*h*) 110	3,215	21,190,777	27,877
1909	490	968	(*l*)	612,020	4,395	(*h*)5,023	3,037	23,350,730	39,815

Year.	Coke.	Peat and Peat Coke.	Briquets	Cobalt and Nickel Ores.	Copper.			
					Ore. and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1897	2,161,886	....	....	....	....	....	7,183	....
1898	2,133,179	....	....	....	....	....	6,972	....
1899	2,137,985	....	....	....	....	....	7,061	....
1900	2,229,188	8,849	550,222	186	25,686	9,787	5,505	1,881
1901	2,096,931	11,588	529,765	96	26,678	7,700	5,097	1,942
1902	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906	3,415,347	15,680	1,095,029	(*i*)	6,414	10,728	7,241	3,018
1907	3,792,580	25,746	1,260 135	(*i*)	20,950	13,411	6,113	2,016
1908	3,577,496	26,817	1,493,054	(*i*)	21,729	17,209	6,868	2,994
1909	3,444,791	23,579	1,620,559	(*i*)	22,498	15,395	6,745	1,292

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1897	...	...	...	2,422	...	26	3,230,391	90,885
1898	...	...	...	2,936	...	26	2,933,734	187,375
1899	...	...	...	2,703	...	26	3,119,878	182,091
1900	3,829	315	12,749	2,068	39,933	29	3,247,888	129,409
1901	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905	4,495	286	15,019	1,971	52,886	27	3,698,563	380,824
1906	4,712	(*k*)	15,493	2,013	63,516	46	3,851,791	479,772
1907	6,212	(*k*)	16,624	2,176	70,737	44	3,904,400	275,170
1908	4,393	(*k*)	14,925	2,469	60,992	51	3,067,737	257,849
1909	2,246	(*k*)	14,545	2,387	63,220	59	2,825,007	471,045

Year.	Lead.					Lime, Chloride of	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1897	...	24,075	...	14,786	...	...	...	...	8,615
1898	...	24,867	...	16,473	...	...	...	...	4,810
1899	...	24,491	...	16,360	...	...	...	...	7,040
1900	1,309	18,825	3,577	15,126	6,603	25,954	2,392	13,375	2,454
1901	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909	2,556	31,656	4,750	10,607	6,114	27,314	3,702	31,326	4,487

Year.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products. (*f*)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1897	...	169	...	...	...	...	4,000
1898	...	203	...	...	...	...	5,100
1899	...	295	...	...	...	...	2,504
1900	13,958	268	1,592	843	1,455	170	1,123
1901	12,671	390	1,700	655	963	149	2,260
1902	14,392	689	1,856	824	1,177	260	1,103
1903	15,161	700	2,027	701	1,975	286	4,342
1904	16,395	1,203	2,447	760	1,763	236	3,222
1905	17,603	1,034	2,757	7,286	1,746	228	3,720
1906	4,290	954	509	673	9,982	228	5,484
1907	4,097	930	692	770	10,552	165	1,494
1908	15,675	1,349	921	1,008	10,852	160	1,196
1909	16,762	1,626	1,289	588	11,621	169	5,429

Year.	Potassium Salts.						Potassium and Potassium-Magnesium Sulphate.	Pumice Stone. (*g*)	Pyrites.
	Carbonate.	Cyanide. (*f*)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1897	13,100	1,086	80,389	...	124	8,986	...	...	15,387
1898	13,456	1,907	96,236	...	135	10,969	...	...	19,220
1899	11,917	1,645	101,045	...	145	15,146	...	...	16,985
1900	15,761	1,338	114,469	15,379	138	14,744	38,125	561	24,936
1901	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909	13,828	6,282	219,870	27,477	122	12,475	201,455	9,140	11,566

Year.	Quick-silver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicar-bonate.	Carbon-ate.	Hydrox-ide.	Nitrate. (Chile Saltpeter)	Soda, Calcined.	Sulphate and Sulphite.
1897	(e)	....	27,723	....	....	....	11,364	45,672	....
1898	97	225,548	29,931	....	....	....	12,884	37,106	....
1899	23	241,036	25,565	....	....	....	13,910	40,566	....
1900	23	236,291	32,494	1,314	1,392	1,913	14,159	44,316	41,572
1901	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909	31	365,049	61,674	1,228	3,149	8,341	28,018	54,499	74,529

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (n)	Salts.		
1897	....	....	337,577	....	....	....	....
1898	....	....	370,829	....	....	....	....
1899	....	....	367,828	....	....	....	....
1900	3,741	2,461	468,277	74	496	1,146	37,738
1901	2,791	2,763	592,347	384	1,022	621	42,853
1902	2,656	4,565	499,220	762	1,546	576	47,666
1903	2,977	5,845	501,385	819	1,389	1,052	50,109
1904	2,272	5,489	631,762	613	1,207	1,418	52,696
1905	2,133	6,569	852,454	613	1,386	1,198	48,701
1906	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909	4,800	7,596	946,514	2,636	1,832	2,002	63,858

Year.	Super-Phosphate.	Tin, Crude.	Zinc.				Zinc-White, Zinc-Gray, and Litho-phone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1897	....	861	30,047	51,341	17,453	....	17,631
1898	....	874	30,408	51,324	14,477	....	18,674
1899	....	1,121	25,192	46,334	18,281	....	19,489
1900	77,118	1,626	34,941	51,899	16,709	382	20,729
1901	79,190	1,683	41,002	54,490	16,517	324	24,201
1902	77,818	2,271	46,965	70,292	17,015	330	28,400
1903	99,672	2,581	40,458	67,057	15,715	264	27,527
1904	129,925	2,965	40,488	70,063	17,917	332	26,898
1905	115,886	3,259	38,972	67,675	18,982	296	27,877
1906	104,713	4,845	42,546	69,142	17,794	426	26,296
1907	115,049	4,244	34,863	93,649	21,484	425	30,453
1908	125,464	3,707	39,450	75,290	18,661	347	26,372
1909	168,988	5,431	52,026	82,365	18,961	342	25,970

(a) From *Statistisches Jahrbuch für das Deutsches Reich.* (b) Includes celestite. (d) Includes precipitated chalk. (e) Not reported. (f) Includes sodium cyanide. (g) Includes tripoli. (h) Includes nickel ore. (i) Included under chromium ore. (k) Included under bauxite. (l) Included under magnesium chloride. (m) Includes all alkali metals. (n) Includes witherite.

GREECE.

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE. (*a*)
(In metric tons or dollars; 1 drachma = 20 cents.)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore. Manganiferous.	Lead. Soft.	Lead Ore. Argentiferous.	Lead. Argentiferous.	Lead. Fume.	Lignite.
1896.......	1,600	3,650	120	225,600	166,850	480	3,200	14,700	1,550	14,000
1897.......	563	3,024	51	260,828	182,850	520	2,815	15,946	2,785	20,018
1898.......	1,367	3,932	83	287,100	213,938	305	(*b*)	18,888	2,655	17,310
1899.......	4,386	4,360	81	331,030	294,320	291	(*b*)	18,768	2,584	12,150
1900.......	5,600	6,328	129	279,880	243,920	245	878	16,150	2,045	12,940
1901.......	4,580	5 691	671	278,640	196,152	(*b*)	(*b*)	17,644	5,292	9,726
1902.......	11 680	4,727	172	364 340	170 040	(*b*)	430	14 048	1,647	6,500
1903.......	8 478	5 586	94	531 804	152,740	(*b*)	(*b*)	12,361	(*b*)	8,687
1904.......	6,530	6,182	117	422,159	108,319	(*b*)	(*b*)	15,186	(*b*)	13,500
1905.......	8,900	6,972	57	465,622	89,687	(*b*)	(*b*)	13,729	(*b*)	11,757
1906.......	11,530	7,718	85	680,620	96,382	(*b*)	(*b*)	12,308	(*b*)	11,582
1907.......	11,730	10,652	105	768,863	92,970	(*b*)	(*b*)	13,814	(*b*)	11,719
1908.......	4,350	7,471	61	515,368	63,857	(*b*)	(*b*)	15,892	(*b*)	8,786

Year.	Magnesite.			Manganese Ore.	Puzzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1896.......	11,600	892	1,514	15,500	31,300	22,800	1,540	1,750	20,950
1897.......	11,311	826	686	11,868	42,600	20,421	358	3,118	22,817
1898.......	14,829	516	129	14,097	70,700	25,250	135	1,139	30,906
1899.......	17,184	542	3,087	17,600	46,375	37,125	1,150	1,137	21,770
1900.......	17,277	534	807	8,050	49,426	22,411	891	(*b*)	18,751
1901.......	20.348	500	2,009	14,166	80,169	23,079	3,212	454	17,764
1902.......	23,020	935	4,730	14,960	32,514	25,200	1,391	(*b*)	18,670
1903.......	28,415	(*b*)	(*b*)	9,340	40,978	26,000	1,266	(*b*)	12,350
1904.......	9,133	(*b*)	(*b*)	8,549	44,644	27,000	1,225	(*b*)	19,913
1905.......	37,063	(*b*)	(*b*)	8,171	41,900	25,201	1,126	(*b*)	22,562
1906.......	40.584	(*b*)	(*b*)	10,040	30,622	25,167	(*b*)	(*b*)	26,258
1907.......	55.816	(*b*)	(*b*)	11,139	39.637	26,966	(*b*)	(*b*)	30,346
1908.......	63,079	(*b*)	(*b*)	10,750	(*b*)	23,988	(*b*)	(*b*)	24,101

(*a*) Statistics up to 1903 communicated by E. Grohmann, Seriphos. (*b*) Not reported.

INDIA.

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA. (*a*)
(In metric tons or dollars: £1 = $5.)

Year.	Amber.	Coal.	Chromite.	Diamonds Carats.	Gold. (*c*)	Graphite.	Iron Ore.	Jade. (*e*) Cwt.	Magnesite.
1896	(*b*)	3,909,764	....	.....	$7,085,432	(*b*)	50,559	215	(*b*)
1897	(*b*)	4,128,330	....	.....	8,041,055	61	61,697	219	(*b*)
1898	$5,080	4,681,927	....	.....	7,798,709	61	(*d*) 42,524	196	(*b*)
1899	755	5,174,752	....	.....	8,357,087	1,548	(*d*) 52,832	228	(*b*)
1900	515	6,222,591	....	.....	9,205,518	1,859	(*d*) 57,912	142	(*b*)
1901	55	6,741,899	....	.....	9,394,723	2,530	(*d*) 58,725	206	(*b*)
1902	2,160	7,543,272	....	.....	9,611,985	4,648	(*d*) 77,273	174	3,597
1903	2,070	7,557,400	248	.....	11,203,926	3,448	(*d*) 62,337	99	838
1904	4,190	8,348,561	3,596	286.5	11,513.340	2,955	72,757	130	1,193
1905	4,725	8,552,422	2,708	172.4	11,760,957	2,361	104,174	106	2,645
1906	3,545	9,939 782	4,375	305.9	10,852,546	2,642	75.295	116	1,861
1907	1,925	11,326,254	18,597	268.0	10,348,795	2,472	68,928	2,636	189
1908	1,820	12,974,588	4,821	140.8	10,597,404	2,919	60,175	3,211	7,655

Year.	Manganese Ore.	Mica.	Petroleum. *Gallons.*	Rubies.	Salt.	Saltpeter (Potassium nitrate.)	Tin Ore.
1896	57,782	452	15,057,094	$171,884	1,043,171	21,425	82
1897	74,862	652	19,128,828	200,613	937,932	26,845	62
1898	61,419	527	22,234,438	289,750	1,043,862	21,224	40
1899	88,524	497	32,934,007	454,240	977,269	18,555	64
1900	129,865	1,025	37,729,211	486,630	1,071,877	20,189	94
1901	122,831	1,505	50,075,117	522,380	1,208,933	17,711	63
1902	160,311	806	56,607,688	434,475	1,116,797	17,320	91
1903	174,563	1,002	87,859,069	444,095	1,021,581	18,711	100
1904	152,601	828	118,491,382	453,060	1,319,535	14,200	63
1905	250,788	1,172	144,798,444	....	1,426,066	15,745	68
1906	579,231	2,458	140,553,122	465,115	1,371,172	16,822	87
1907	916,770	2,652	152,045,677	491,290	1,120,453	18,664	77
1908	685,135	2,720	176,646,320	239,770	1,300,480	19,620	96

(*a*) Records of the Geological Survey of India. (*b*) Not reported. (*c*) £1 = $4.866. (*d*) Production of iron ore in Bengal only. (*e*) Exports in cwt. of 112 lbs.

ITALY.

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY. (a)
(In metric tons or dollars; 5 lire=$1.)

Year.	Alum.	Aluminum Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic and Bitumen.	Asphaltic Rock.	Barytes.
1895......	995	2,950	7,000	423	2,241	14,491	46,713	(b)
1896......	850	2,390	6,000	538	5,086	12,490	45,456	(b)
1897......	1,030	2,310	6,500	404	2,150	18,644	55,339	(b)
1898......	1,165	2,915	7,000	380	1,931	17,813	93,750	12,400
1899......	945	2,330	5,800	581	3,791	41,732	81,987	12,545
1900......	1,097	2,403	5,200	1,174	7,609	33,127	101,738	14,003
1901......	1,075	2,260	4,900	1,721	8,818	31,814	104,111	13,245
1902......	....	....	8,200	1,574	6,116	33,684	64,245	....
1903......	....	....	8,100	905	6,927	35,757	89,078	....
1904......	2,490	2,210	8,000	836	5,712	34,227	111,390	250
1905......	2,975	2,740	8,500	327	5,083	26,838	106,586	590
1906......	2,878	2,800	7,500	537	5,704	34,386	130,225	800
1907......	3,175	3,010	7,600	610	7,892	38,568	161,126	1,720
1908......	2,875	2,100	6,165	345	2,825	34,761	134,163	1,895

Year.	Borax. Refined.	Boric Acid.		Coal. (c)	Coal. (Briquettes).	Coke	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1895......	944	2,633	253	305,321	451,470	394,043	83,670	2,375	....
1896......	943	2,616	253	276,197	422,409	426,906	90,408	2,842	4,756
1897......	990	2,704	260	314,222	549,050	430,617	93,377	2,980	5,337
1898......	702	2,650	166	341,327	594,500	469,228	95,128	3,230	6,364
1899......	709	2,674	129	388,534	566,000	485,951	94,764	3,032	7,795
1900......	858	2,491	283	479,896	703,740	487,831	95,644	2,797	13,191
1901......	544	2,558	347	425,614	754,800	490,803	107,750	3,097	15,374
1902......	....	2,763	....	414,569	....	....	101,142	....	14,601
1903......	....	2,583	....	346,887	724,993	554,559	114,823	....	18,164
1904......	569	2,624	314	362,151	903,610	607,297	157,503	2,313	17,237
1905......	1,007	2,700	749	412,916	842,250	627,984	149,035	1,175	26,212
1906......	1,062	2,561	562	473,293	829,277	672,689	147,137	....	34,270
1907......	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908......	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1895......	7,099	$186,074	2,657	183,371	9,213	163,824	5,860	50,314
1896......	7,659	172,552	3,148	203,966	6,987	139,991	2,918	65,955
1897......	10,723	209,998	5,650	200,709	8,393	149,944	6,500	63,940
1898......	9,549	124,869	6,435	190,110	12,387	167,499	7,200	87,467
1899......	11,859	75,294	9,990	236,549	19,218	197,730	8,000	108,501
1900......	5,840	38,212	9,720	247,278	23,990	190,518	10,000	115,887
1901......	890	2,725	10,313	232,299	15,819	180,729	7,550	123,310
1902......	1,215	....	9,210	240,705	....	....	....	....
1903......	5,734	41,933	7,920	374,790	90,744	177,392	11,275	154,134
1904......	6,746	43,063	9,765	409,460	112,598	181,385	16,655	177,086
1905......	1,200	9,169	10,572	366,616	181,248	205,915	18,560	244,793
1906......	6,543	47,321	10,805	384,217	180,940	236,946	16,350	332,924
1907......	13,475	33,582	10,989	517,952	148,996	248,157	24,423	346,749
1908......	14,671	39,930	12,914	539,120	158,100	302,509	28,277	437,674

Year.	Lead.		Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum, Crude.	Petroleum, Benzine, etc.	Pumice-Stone.
	Ore.	Pig.						
1895	30,632	20,353	1,569	5,860	186,900	3,594	4,191	(b)
1896	33,545	20,786	1,890	10,000	209,428	2,524	2,734	(b)
1897	36,200	22,407	1,634	21,262	236,958	1,932	3,392	(b)
1898	33,930	24,543	3,002	11,150	271,725	2,015	5,040	2,766
1899	31,046	20,543	4,356	29,874	313,744	2,242	5,384	7,300
1900	35,103	23,763	6,014	26,800	310,336	1,683	6,077	7,000
1901	43,449	25,796	2,181	24,290	334,146	2,246	4,211	8,300
1902	42,330	26,494	2,477	23,113	....	2,633	....	....
1903	42,443	22,126	1,930	4,735	....	2,486	4,577	....
1904	42,846	23,475	2,836	2,836	390,118	3,543	6,388	11,600
1905	39,030	19,077	5,384	5,384	389,869	6,122	9,924	11,300
1906	40,945	21,268	3,060	20,500	430,202	7,452	(f) 2,322	16,366
1907	(d)43,037	22,978	3,654	18,874	434,612	8,326	(f) 2,989	11,500
1908	46,649	26,003	2,750	17,812	425,600	7,088	(f) 2,273	15,000

Year.	Pyrites. (Cupriferous in part).	Quicksilver.		Salt.			Silver.	
		Ore.	Metal.	Brine.	Rock.	Sea.	Ore.	Bullion. Kg.
1895	38,586	10,504	199	10,605	18,710	448,335	870	44,189
1896	45,728	14,305	186	11,974	17,300	422,555	640	38,075
1897	58,320	20,659	192	11,725	19,801	429,253	405	45,313
1898	67,191	19,201	173	11,546	18,199	451,426	435	43,437
1899	76,538	29,322	205	11,021	18,721	363,826	540	33,645
1900	71,616	33,930	260	10,890	18,331	338,034	584	31,169
1901	89,376	38,614	278	10,690	23,054	401,443	511	32,464
1902	93,177	44,261	....	10,581	23,677	424,239	421	....
1903	101,455	55,528	312	10,962	25,911	451,633	405	24,388
1904	112,004	60,403	352	11,878	18,638	433,810	143	24,943
1905	117,667	63,378	369	12,756	19,669	405,274	170	20,215
1906	122,364	80,638	417	13,751	19,007	496,872	48	20,362
1907	126,925	76,561	434	19,238	31,540	454,454	62	20,502
1908	131,721	82,534	684	15,180	24,033	473,857	53	20,746

Year.	Sulphur.			Talc. Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1895	370,766	91,517	75,329	(b)	121,197	*Nil.*
1896	426,353	89,292	71,072	(b)	118,171	*Nil.*
1897	496,658	69,178	85,872	(b)	122,214	250
1898	502,351	146,001	99,494	12,760	132,099	250
1899	563,697	161,509	110,213	11,000	150,629	251
1900	544,119	167,466	157,957	14,415	139,679	547
1901	563,096	171,252	141,431	11,770	135,784	511
1902	510,333	....	....	....	131,965	....
1903	553,751	139,376	139,464	6,300	157,521	126
1904	527,563	189,266	163,695	6,740	148,365	189
1905	568,927	180,676	180,774	6,626	147,834	5
1906	499,814	176,476	170,990	7,894	155,751	69
1907	426,972	151,338	160,617	8,850	160,517	188
1908	445,312	160,693	156,995	9,410	(e) 152,814	(b)

(a) From *Rivista del Servizio Minerario.* (b) Not reported. (c) Includes anthracite, lignite, fossil wood and bituminous schist. (d) Does not include 680 tons lead and zinc ore. (e) Includes 560 tons lead-zinc ore. (f) Benzine and benzol.

MINERAL IMPORTS OF ITALY. (a)
(In metric tons or dollars; 5 lire = $1.)

Year.	Antimony	Arsenic. Kg.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric acid.	Cement and Hydraulic Lime.	Chalk.
1896	38	(b)	851	11,892	549	166	12,810	15,716
1897	66	2,604	619	1,632	578	253	16,680	28,937
1898	58	700	1,186	1,150	860	147	12,029	18,252
1899	64	600	1,675	1,473	936	123	14,391	13,738
1900	37	900	1,645	1,933	859	122	15,494	18,436
1901	49	1,800	2,019	1,450	825	232	14,872	20,731
1902	80	1,200	1,536	1,020	1,170	516	13,732	15,216
1903	98	4,400	1,691	1,567	1,099	504	15,547	10,063
1904	131	3,700	2,174	2,604	1,875	271	15,260	6,891
1905	117	3,400	1,806	3,252	1,444	112	15,797	5,556
1906	50	5,300	2,171	2,354	1,400	163	18,937	7,714
1907	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909	293	4,800	2,285	3,826	2,094	386	25,250	11,120

Year.	Coal.	Copper Ore.	Copper Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold, Unrefined. Kg.	Graphite.
1896	4,081,218	484	1,150	6,955	24,255	2,517	204
1897	4,259,643	1,611	1,049	7,999	28,878	807	315
1898	4,431,524	5,471	2,040	7,433	25,560	507	382
1899	4,859,556	2,777	1,328	7,334	27,408	326	608
1900	4,947,180	5,290	1,298	9,249	32,127	309	982
1901	4,838,994	11,047	1,987	8,659	32,058	494	102
1902	5,406,069	9,422	2,299	10,865	25,107	479	60
1903	5,546,823	9,459	649	9,588	24,566	1,396	63
1904	5,904,578	8,104	309	15,198	37,298	1,961	52
1905	6,437,539	6,879	486	18,188	30,684	5,768	107
1906	7,673,435	9,363	802	21,458	25,060	4,571	361
1907	8,300,439	18,023	888	28,937	15,939	4,443	267
1908	8,452,320	14,784	344	28,025	25,037	1,909	383
1909	9,264,311	11,303	630	22,391	9,050	5,490	141

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead. Oxide and Carbonate	Mineral Paints.
	Ore.	Pig.		Ore. (c)	Metal and Alloys in Pigs.		
1896	594	119,491	162,035	9,730	1,166	523	852
1897	5,831	156,019	130,938	14,854	1,178	580	888
1898	8,723	169,059	138,426	10,947	1,431	647	692
1899	20,799	191,613	245,616	7,476	3,990	662	958
1900	19,205	160,686	197,415	9,134	3,248	557	958
1901	4,054	159,972	148,305	9,063	2,926	815	865
1902	4,314	155,143	198,914	1,680	7,563	846	670
1903	5,937	126,756	206,036	689	5,398	768	859
1904	4,390	149,130	246,359	2,187	4,541	871	940
1905	4,745	136,077	276,311	465	6,764	686	974
1906	6,452	168,985	344,977	4,526	10,958	984	964
1907	22,046	231,042	362,567	4.342	9,231	953	1,119
1908	31,090	254,239	326,119	5,620	11,742	1,474	982
1909	28,150	246,730	416,354	3,003	10,011	1,132	967

Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia and Caustic Soda.	Potassium Sulphate.	Quick-Silver.	Silver, Unrefined in Bars. *Kg.*	Slag.
1896	411	70,217	(*b*)	9,841	431	30	2,291	30,275
1897	432	68,973	(*b*)	11,012	562	30	2,434	37,201
1898	258	70,654	65,126	11,047	928	39	991	51,199
1899	250	71,391	116,283	12,370	1,297	62	1,782	56,549
1900	232	73,089	140,281	14,077	1,670	49	2,678	32,254
1901	476	69,298	142,108	14,693	1,411	36	4,391	7,312
1902	561	68,781	159,341	17,617	1,566	57	8,768	5,634
1903	525	68,220	172,328	17,528	1,353	28	12,541	8,849
1904	652	69,233	217,162	14,846	1,663	25	15,885	3,821
1905	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908	1,079	82,373	531,921	14,962	4,891	10	32,303	1,122
1909	740	88,929	478,199	15,861	5,333	2	39,208	878

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfres.	Ore.	Oxide.	Spelter and Old.	Mnfres.
1896	18,927	11,685	541	1,763	91	(*b*)	540	2,596	3,482
1897	20,721	16,400	917	1,520	81	(*b*)	570	3.278	3,556
1898	20,845	19,961	702	1,722	109	216	573	2,813	3,200
1899	22,654	22,385	671	1,240	96	(*b*)	804	3,498	3,221
1900	23,215	27,706	511	1,643	56	85	1,034	3,627	3,543
1901	21,956	40,498	315	1,858	91	23	813	3,991	4,079
1902	26,133	24,483	314	2,114	110	131	904	3,805	4,167
1903	24,753	43,480	638	2,288	130	46	1,416	4,551	4,461
1904	27,747	32,283	613	2,170	150	362	1,124	5,202	4,168
1905	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909	38,252	43,658	532	2,555	191	13	1,571	9,222	4,872

MINERAL EXPORTS OF ITALY. (*a*)

(In metric tons or dollars; 5 lire=\$1.)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Chalk.	Coal.
1896	361	130	13,729	66	2,719	3,871	5,593	18,924
1897	271	170	15,310	143	1,618	5,330	7,556	23,191
1898	338	208	19,465	70	2,167	5,192	6,744	17,749
1899	240	245	26,402	45	2,872	5,462	5.386	20,803
1900	467	261	24,287	40	2,114	6,860	2,980	23,926
1901	765	302	21,856	32	2,190	8,463	3,428	25,594
1902	359	144	20,884	91	1,847	7,930	4,215	33,374
1903	314	222	24,303	35	901	6,325	3,802	29,219
1904	107	163	14,880	70	1,122	7,810	4,089	35,149
1905	132	236	23,740	162	2,255	8,445	5,007	38,555
1906	208	205	27,176	147	2,777	6,774	4,194	31,666
1907	115	142	26,036	152	1,330	4,477	3,118	40,769
1908	10	193	24,158	724	1,005	5,439	3,224	46,774
1909	8	527	21,978	125	1,704	7,534	2,533	51,343

Year.	Copper Ore.	Copper, and Iron Sulphate.	Gold. Unrefined. *Kg.*	Graphite.	Iron.	
					Ore.	Pig.
1896	3,603	71	2,517	3,727	187,059	1,378
1897	2,408	18	1,381	4,164	207,619	498
1898	2,356	25	1,739	5,145	217,556	840
1899	1,148	20	1,162	8,114	234,515	378
1900	1,179	60	2,763	7,820	170,286	329
1901	9	20	2,955	7,169	121,592	311
1902	11	39	733	7,098	209,070	395
1903	15	44	1,291	7,068	98,319	810
1904	43	29	1,494	7,433	2,577	229
1905	77	249	1,731	6,811	11,358	1,395
1906	189	102	1,476	4,904	1,833	254
1907	179	835	802	7,474	26,000	121
1908	188	721	4,739	7,009	35,653	176
1909	2333	1,211	8,517	8,125	46	209

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quick-silver.	Salt.	Silver, Unrefined. *Kg.*
	Ore.	Lead Alloys in Pigs.	Oxide and Carbonate.					
1896	4,731	1,419	489	2,412	(*b*)	155	171,740	26,854
1897	4,747	2,790	461	2,318	(*b*)	236	176,520	50,503
1898	4,492	5,870	414	2,884	(*b*)	244	126,860	68,607
1899	3,129	2,497	389	2,784	(*b*)	223	114,050	32,432
1900	3,741	5,018	367	2,977	1,726	259	112,900	25,310
1901	3,977	4,463	410	2,913	1,290	301	114,210	42,325
1902	3,354	5,650	404	2,953	894	215	145,190	20,427
1903	5,041	2,911	426	3,305	2,942	222	144,910	9,486
1904	5,524	1,954	347	3,231	2,812	266	130,940	24,165
1905	4,311	976	310	3,632	3,519	243	116,040	25,947
1906	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908	2,041	1,243	219	3,319	2,271	565	85,489	26,138
1909	1,037	776	138	4,289	2,979	714	103,895	34,470

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbon-ate.	Nitrate. (Crude.)	Sod. and Pot. Nitrates, Refined.		Block.	Manufac-tures.	Ore.	Oxide.	Spelter and Scrap.
1896	4,753	279	51	306	356,370	10	89	115,454	48	33
1897	8,847	275	151	344	358,932	29	109	133,125	189	309
1898	6,861	391	79	256	405,823	34	177	130,064	110	156
1899	4,898	438	136	124	424,018	69	176	140,107	123	227
1900	4,222	486	58	129	479,139	147	153	111,870	102	359
1901	3,261	377	116	59	414,018	202	187	103,020	140	349
1902	3,615	446	346	259	439,242	236	174	114,894	122	338
1903	4,929	482	781	492	461,289	173	180	116,449	116	591
1904	4,458	376	363	230	437,067	171	151	126,393	483	263
1905	9,844	214	424	159	381,128	285	107	117,810	173	434
1906	8,990	253	80	133	336,339	303	81	144,244	687	639
1907	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908	12,122	583	37	57	330,093	180	173	122,456	395	984
1909	17,163	517	464	163	329,233	647	126	123,936	282	983

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore.

JAPAN.

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified:

MINERAL PRODUCTION OF JAPAN. (a)

Year.	Antimony.		Arsenic. *Kg.*	Coal.	Copper.	Gold. *Kg.*	Graphite	Iron. Pig.	Lead.
	Ore.	Metal.							
1894....	1,172	403	5,387	4,300,370	19,814	806	1,091	19,474	1,577
1895....	1,061	641	7,343	4,770,313	19,103	935	77	25,863	1,978
1896....	828	517	6,043	5,100,005	20,114	964	215	27,420	1,958
1897....	348	823	13,039	5,147,103	20,425	1,037	391	28,040	1,737
1898....	1,005	235	7,129	6,643,047	21,023	1,159	347	23,611	1,703
1899....	712	229	5,077	6,668,608	19,421	1,675	53	23,066	1,963
1900....	81	349	4,669	7,370,667	24,317	2,124	94	24,841	1,878
1901....	118	429	10,312	8,884,812	27,392	2,475	88	29,449	1,803
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907(*d*).	(*b*)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908(*d*).	(*b*)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909(*d*).	(*b*)	201	7,311	15,213,946	42,987	3,762	284	44,254	3,216

Year.	Manganese Ore.	Petroleum *Gallons.*	Phos-phates.	Pyrite.	Quicksil-ver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1894....	13,368	(c)5,426,071	(*b*)	(*b*)	1,547	11,411,275	79,222	18,787	38.7
1895....	17,142	7,118,962	(*b*)	(*b*)	481	(*b*)	74,815	15,557	48.3
1896....	17,967	(c)7,440,206	(*b*)	(*b*)	1,762	(*b*)	64,303	12,540	50.0
1897....	15,448	9,179,474	(*b*)	7,626	2,678	(*b*)	54,289	13,582	47.6
1898....	11,497	11,145,457	(*b*)	8,726	1,399	11,482,422	60,436	10,321	42.7
1899....	11,336	18,844,034	(*b*)	8,376	....	10,483,082	56,161	10,237	18.5
1900....	15,831	30,470,068	(*b*)	16,166	270	11,890,361	58,799	14,439	12.3
1901....	16,270	39,056,820	(*b*)	17,589	750	12,463,771	54,739	16,548	14.1
1902....	10,844	34,850,129	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	50,724,174	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	51,573,754	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	47,132,800	1,519	25,569	349	(*b*)	82,886	24,652	26.0
1906....	54,339	60,005,957	3,037	36,038	336	(*b*)	76,247	27,589	77.0
1907(*d*)..	20,586	60,110,558	1,721	56,166	456	(*b*)	95,600	33,329	31.8
1908(*d*).	11,130	65,165,860	740	33,867	804	(*b*)	123,180	33,149	25.7
1909(*d*).	6,660	65,684,682	1,361	27,066	512	(*b*)	129,294	35,480	17.8

(*a*) From *Résumé Statistique de l'Empire du Japon*, Tokio. (*b*) Not reported. (*c*) Crude petroleum. (*d*) From reports of the Japanese Department of Agriculture and Commerce.

MEXICO.

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO. (a)
(In metric tons or Mexican dollars.)

Year.	Antimony		Coal.	Copper.		Gold.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1895....	......	600	61,686	3,006	20,429	$ 103,773	$ 4,920,504	$ 175,098	$ 31,231	$ 3,026
1896....	......	3,261	75,541	144	20,659	206,874	5,533,789	261,078	161,784	44,890
1897....	......	5.873	105,298	1,094	16,858	365,226	6,220,765	202,223	226,986	33,916
1898....	......	5,932	118,553	13,146	10,362	1,037,202	6,493,735	367,704	294,730	64,061
1899....	......	10,382	113,192	223	25,293	335,849	7,017,286	183,474	115,961	266,782
1900....	......	2,313	38,676	408	27,970	306,392	7,435,864	192,456	128,675	177,193
1901....	......	5,103	17,281	5,576	33,818	284,722	8,324,681	210,431	178,803	81,744
1902....	1,218	1,280	3,406	6,101	63,609	303,979	9,079,371	129,899	78,295	40,658
1903....	2,304	7,302	1,840	10,912	51,716	264,503	9,693,692	54,636	85,465	124,020
1904(c).	1,694	81	125	48,365	57,338	537,290	10,867,272	172,532	79,129	176,090
1905....	1,978	57	497	92,540	56,634	1,513,344	29,636,117	106,470	397,814	138,033
1906....	2,418	178	91	73,193	46,767	5,369,173	21,072,014	37,746	337,294	180,348
1907....	4,615	681	1,532	115,245	51,519	3,033,090	19,653,362	5,023,404	417,162	497,893
1908....	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944

Year.	Graph-ite.	Gyp-sum.	Lead.		Silver.					
			Ore.	Base Bul-lion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1895...	794	1,340	568	50,122	$10,977,079	$22,178,294	$18,300,553	$ 555,475	$14,649	$72,590
1896...	795	2,050	167	48,663	9,971,053	28,565,843	18,737,331	1,495,306	38,049	64,121
1897...	759	2,095	2	60,029	11,401,176	35,775,125	21,925,347	1,663,581	123,246	39,800
1898...	1,365	1,650	(b)	60,918	11,048,358	37,137,599	16,588,789	1,663,501	257,342	46,488
1899...	2,305	1,050	1	67,441	10,766,099	37,585,911	5,580,834	1,929,085	76,942	4,819
1900...	2,561	1,600	468	74,944	12,495,524	41,468,745	22,679,655	1,893,646	67,607	87,880
1901...	762	800	(b)	79,097	9,615,939	36,348,374	12,038,158	2,141,685	259,282	93,543
1902...	1,434	(b)	118	107,366	4,108,088	45,796,576	17,753,526	1,978,919	108,344	132,093
1903...	1,404	(b)	11	100,532	11,781,048	48,276,797	16,167,673	1,642,627	135,561	289,900
1904(c)	970	(b)	1	95,010	11,000,869	45,430,020	7,251,132	1,392,356	171,452	202,594
1905...	970	27	1	101,196	8,505,834	63,564,789	20,335,297	736,228	438,094	29.012
1906...	3,915	(b)	(b)	73,699	9,619,763	63,057,152	42,390,357	595,112	434,885	(b)
1907...	3,202	(b)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	785,116
1908...	1,076	(b)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,848	(b)

(a) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (b) Not reported. (c) Figures for 1904 were from *Anuario Estadistico de la República Mexicana* for 1904.

NORWAY.

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY. (*a*)
(In metric tons or dollars; 1 Krone=27 cents.)

Year.	Apatite. (*b*)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore.	Pig and Cast.	Bars and Steel.
1896......	1,106	....	29,910	1,067	12,223	$9,450	2,000	335	400
1897.....	872	....	27,606	1,064	17,392	675	3,627	417	452
1898......	3,593	....	37,047	941	11,355	1,539	4,425	231	379
1899.....	1,500	41	43,358	1,209	19,260	2,700	4,576	406	666
1900......	300	165	46,858	1,280	17,609	2,430	17,925	444	614
1901......	738	85	40,726	1,073	18,323	2,700	42,252	261	376
1902......	2,295	22	40,499	1,347	19,591	36,990	53,675	527	461
1903.....	1,795	*Nil.*	35,417	1,382	18,590	8,370	53,475	509	442
1904......	1,456	154	36,891	1,342	20,835	*Nil.*	45,328	350	395
1905......	2.522	*Nil.*	37,045	1,153	22,508	*Nil.*	46,582	474	253
1906.....	3,482	*Nil.*	32,203	1,333	23,896	5.400	109,259	257	317
1907......	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908......	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	....	....

Year.	Molybdenite.	Nickel.		Pyrites, Iron and Copper.	Rutile.	Silver.		Zinc Ore. (*c*)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1896......	......	*Nil.*	16	60,507	30	527	4,664	450
1897......	......	*Nil.*	*Nil.*	94,484	32	642	5,372	908
1898......	......	*Nil.*	*Nil.*	89,763	35	497	4,802	320
1899......	......	220	5	95,636	30	429	4,600	379
1900......	......	1,888	13	98,945	40	475	4,600	204
1901......	......	2,018	40	101,894	55	519	5,680	90
1902......	20	4,040	60	121,247	*Nil.*	471	6,220	30
1903......	31	5,670	75	129,939	25	481	7,269	335
1904......	30	5,352	73	133,603	25	1,297	8,064	42
1905......	46	5,477	77	162,012	35	1,570	7,100	4,241
1906......	1,026	6,081	81	197,886	55	1,565	6,370	3,308
1907......	30	5,781	81	236,038	55	1,756	6,700	400
1908......	35	5,190	62	269,129	83	2,262	7,470	2,435

(*a*) *Tabeller vedkommendo Norges Bergværkdsdrift, Statistik Aarbog for Kongeriket Norge.* (*b*) Exports which represent production. (*c*) Includes lead ore.

MINERAL IMPORTS OF NORWAY. (*a*)
(In metric tons.)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1896......	38,305	16,028	....	1,074	479	......	26,552
1897......	44,495	18,734	15,374,572	1,140	591	21,606	29,038
1898......	71,590	25,403	15,409,902	1,064	807	23,106	26,203
1899......	62,060	33,652	18,475,996	1,000	1,120	21,445	25,379
1900......	71,124	24,511	19,002,026	696	1,164	20,844	23,010
1901......	68,000	20,993	17,665,349	1,018	761	19,112	20,672
1902......	(c)	18,984	19,338,615	1,118	(c)	18,969	26,685
1903......	(c)	17,906	20,086,974	899	309	20,652	21,977
1904......	54,953	12,845	21 049,128	688	866	18,891	24,094
1905......	(c)	13,797	20,973,608	882	1,146	20,828	27,740
1906......	63,000	11,676	21,478,000	906	783	20,197	26,015
1907......	79,810	16,647	24,274,260	(*f*) 954	1,107	23,345	32,764
1908......	87,255	44,991	(*e*) 2,073,907	(*f*)1,013	1,157	26,106	31,849

Year.	Iron and Steel—Continued.						Lead in Pigs and Sheets.
	Anchors, Cables and Chains.	Rails.	Nails, Spikes and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1896.......	1,090	4,315	1,760	2,754	17,930	6,831	653
1897.......	1,367	7,637	2,097	4,350	23,350	10,695	848
1898.......	1,485	10,327	2,087	2,428	26,894	17,182	732
1899.......	1,394	8,137	1,529	2,652	32,192	21,400	869
1900.......	1,203	11,952	1,219	2,085	29,318	17,493	670
1901.......	1,708	22,959	1,808	1,905	31,184	18,372	590
1902.......	2,103	15,316	2,205	1,754	36,288	22,069	(c)
1903.......	1,807	4,631	1,261	1,958	42,098	18,855	311
1904.......	2,109	5,814	1,071	1,610	42,013	5,462	498
1905.......	2,224	6,566	1,222	1,436	42,203	44,414	448
1906.......	2,585	8,086	1,012	2,018	48,969	45,959	727
1907.......	2,653	6,989	991	1,592	44,432	48,965	1,192
1908.......	2.535	12,180	1,032	1,628	42,832	52,594	1,006

Year.	Lead White and *Zinc* Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Salt-peter.	Soda.	Sulphur. (*b*)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1896.......	1,192	35,823	945	117,920	308	5,156	9,347	142	1,101
1897.......	1,119	39,810	919	164,572	277	5,492	10,701	236	1,102
1898.......	1,491	36,504	754	127,341	477	4,823	9,589	257	1,370
1899.......	1,296	42,182	802	134,583	278	4,555	10,734	546	1,509
1900.......	1,216	39,657	638	143,365	356	4,576	14,827	149	1,254
1901.......	1,321	47,011	518	127,607	208	5,220	11,149	141	1,027
1902.......	(*c*)	(*c*)	(*c*)	141,415	315	(*c*)	(*c*)	(*c*)	1,104
1903.......	(*c*)	58,822	457	143,110	245	4,200	8,829	106	1,015
1904.......	1,898	50,543	477	153,699	321	3,197	12,181	176	940
1905.......	1,309	43,860	393	137,800	1,048	3,704	10,240	134	967
1906.......	1,149	41,546	396	167,300	776	4,334	11,465	261	2,791
1907.......	1,245	44,124	588	163,458	1,004	5,819	11,412	332	3,549
1908.......	1,201	64,468	504	177,349	935	7,850	12,281	323	1,418

MINERAL EXPORTS OF NORWAY. (*a*)
(In metric tons.)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron.
		Ore.	Ingot.	Scrap.			Ore.
1896.......	1,160	30,367	1,276	712	12,223	1,959	2,051
1897.......	872	15,111	1,222	670	17,392	2,395	4,242
1898.......	3,593	13,587	1,650	1,206	11,355	5,474	4,601
1899.......	1,500	7,198	1,785	1,038	19,260	16,180	12,517
1900.......	300	5,756	1,891	1,168	17,609	11,210	27,158
1901.......	738	6,041	1,465	774	(*d*) 18,423	10,000	39,173
1902.......	2,295	4,848	1,913	(*c*)	(*d*) 19,611	......	48,775
1903.......	1,795	3,448	1,930	888	(*d*) 18,640	11,417	41,575
1904.......	1,456	2,673	1,124	785	20,835	9,414	45,434
1905.......	2,522	3.393	958	968	20,696	12,000	60,558
1906.......	3,482	84	875	964	19,669	13,248	81,398
1907.......	1,830	1,581	1,033	1,644	29,399	13,780	132,593
1908.......	1,771	156	1,260	385	29,896	11,097	110,425

Year.	Iron—Continued.				Nickel Ore.	Pyrites.	Silver Ore.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1896.......	5,493	12	10,664	132	*Nil.*	41,562	174
1897.......	4,631	56	9,097	167	*Nil.*	70,552	119
1898.......	3,844	25	7,270	158	30	67,502	79
1899.......	6,085	337	6,089	377	63	83,912	14
1900.......	8,141	135	5,643	220	272	84,604	90
1901.......	3,250	370	6,[illegible]01	179	55	104,151	6
1902.......	7,359	166	6,[illegible]1	240	1	105,980	*Nil.*
1903.......	6,350	10	6,504	200	*Nil.*	118,148	*Nil.*
1904.......	10,152	13	7,477	167	30	116,550	*Nil.*
1905.......	9,920	34	8,725	88	220	147,155	*Nil.*
1096.......	7,362	8	6,786	21	*Nil.*	164,119	*Nil.*
1907.......	4,652	7	5,879	31	11	187,983	*Nil.*
1908.......	6,787	2	4,839	17	*Nil.*	218,851	*Nil.*

(*a*) From *Tabeller vedkommende Norges Bergvaerksdrift und Tabeller vedkommende Norges Handel.* (*b*) Includes flowers of sulphur. (*c*) Returns not available. (*d*) Includes a small quantity of fluorspar. (*e*) Metric tons. (*f*) Includes a quantity of sheet aluminum.

PORTUGAL.

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL. (*a*)
(In metric tons.)

Year.	Antimony. Ore.	Arsenic Ore.	Coal. (Anthracite) (*c*)	Copper.			
				Copper-Iron Pyrite. (*e*)	Other Ores.	Cement.	Matte.
1895	753	(*b*)	8,787	195,304	202	5,055	(*b*)
1896	595	(*b*)	8,743	207,440	436	3,453	(*b*)
1897	418	524	7,996	2 6,738	241	3,304	(*b*)
1898	245	751	10,250	302,686	290	3,145	(*b*)
1899	59	1,083	11,930	347,234	408	2,521	(*b*)
1900	38	1,031	24,066	402,870	(*b*)	2,948	(*b*)
1901	(*b*)	527	16,000	443,397	(*b*)	2,061	(*b*)
1902	68	736	11,000	413,714	655	2,205	(*b*)
1903	83	698	8,063	376,177	527	2,448	(*b*)
1904	31	1,370	12,805	383,581	297	(*b*)	(*b*)
1905	84	1,562	11,449	352,479	210	2,148	(*b*)
1906	481	1,322	6,762	350,746	196	3,634	(*b*)
1907	383	1,538	8,824	241,771	2,478	2,942	298
1908	76	1,655	4,614	81,417	15,455	3,041	564

Year.	Gold. *Kg.*	Iron Ore.	Lead Ore. (Galena)	Manganese Ore.	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1895	(*d*)222.0	(*b*)	1,346	1,240	(*e*)	3	12
1896	(*b*)	(*b*)	1,333	1,494	(*e*)	6	14
1897	(*d*) 17.0	(*b*)	2,180	1,652	(*e*)	9	29
1898	(*d*) 6.8	2,519	3,242	907	(*e*)	102	59
1899	(*d*) 13.0	15,078	3,468	2,949	(*e*)	30	55
1900	2.6	19,803	3,620	1,970	(*e*)	81	49
1901	2.0	21,599	445	904	(*e*)	31	90
1902	2.0	19,914	1,651	(*b*)	(*e*)	24	234
1903	1.3	15,200	830	30	(*e*)	(*b*)	228
1904	*Nil.*	12,488	291	(*b*)	(*e*)	51	290
1905	*Nil.*	3,200	50	(*b*)	(*e*)	20	358
1906	*Nil.*	(*b*)	511	22	(*e*)	22	570
1907	10.5	(*b*)	510	1,374	123,393	35	226
1908	57.0	(*b*)	481	(*b*)	24,522	28	106

(*a*) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas except for 1904 to 1906 inclusive, which are from official Government reports. The mineral production of the country is identical with exports except in the case of coal. (*b*) Not reported. (*c*) Consumed in the country. (*d*) Metric tons of ore. (*e*) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

RHODESIA.

The statistics of the mineral production of Rhodesia for the last 10 years are given in the subjoined table.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (a).

	Gold Ozs.	Value.	Silver. Ozs.	Lead. Tons. (b)	Coal. Tons. (b)		Gold. Ozs.	Value.	Silver. Ozs.	Lead. Tons. (b)	Coal. Tons. (b)
1899..	56,742	$ 999,620	112	....	....	1904..	267,737	$4 711,016	70,146	455	59,678
1900..	85,367	1,498,100	951	....	....	1905..	407,048	7,046,692	89,278	570	97,191
1901..	172,035	2,966,490	3,132	....	....	1906..	551,894	9,647,581	110,575	652	103,803
1902..	194,170	3,339,286	3,445	....	....	1907..	612,052	10,589,385	147,324	756	115,073
1903..	231,872	4,022,756	20,715	....	....	1908..	606,962	12,276,394	283,424	1,069	164,114

(a) From report of Colonel Seely, Under-Secretary of State for the colonies. (b) Long tons.

RUSSIA.

The mineral and metallurgical production of Russia, according to official statistics especially reported to THE MINERAL INDUSTRY, is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA. (a)
(In metric tons; one metric ton = 61.05 poods.)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (b)	Pig-iron.	Lead.	Manganese Ore.
1895	1,131	21,014	9,098,486	5,854	$24,198,383	1,452,338	411.9	203,081
1896	1,275	6,682	9,377,560	5,832	21,667,269	1,620,814	261.5	191,645
1897	1,016	13,433	11,202,750	6,940	22,194,664	1,880,130	450.1	263,115
1898	1,665	15,466	12,307,463	7,290	22,195,208	2,241,293	241.2	329,276
1899	2,693	19,146	13,974,376	7,533	22,396,315	2,708,752	321.8	659,302
1900	3,845	18,233	16,156,055	8,258	22,369,864	2,933,786	220.7	802,236
1901	4,398	22,169	16,526,652	8,467	22,763,967	2,866,779	156.0	522,395
1902	4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
1903	5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
1904	7,502	26,575	19,608,631	9,835	24,627,537	2,972,115	90.3	430,090
1905	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907	9,398	25,528	25,741,321	15,930	26,518,253	3,041,570	520.0	995,282
1908	10,903	9,278	9,481,027	17,118	33,143,810	2,818,450	522.5	362,303

Year.	Petroleum.	Phosphate Rock.	Platinum. (*Kg.*)	Pyrites.	Quick-silver.	Salt.	Silver. (*Kg.*)	Sulphur.	Zinc.
1895	6,290,000	6,327	4,414	11,042	434	1,540,195	7,887	190	5,030
1896	6,371,826	3,776	4,930	11,550	491	1,346,118	7,808	437	6,257
1897	6,945,127	5,917	5,601	19,380	616	1,561,895	4,779	574	5,874
1898	8,009,828	1,867	6,016	24,570	362	1,505,602	5,143	1,018	5,664
1899	8,517,608	16,863	5,962	23,250	362	1,679,726	4,419	451	6,326
1900	9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
1901	10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
1902	10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
1903	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906	8,167,934	13,891	5,776	20,660	210	1,730,934	430	39	9,602
1907	9,098,931	(c)	5,903	18,316	130	1,873,171	7,843	(d)57	10,409
1908	8,732,301	(c)	4,883	56,345	47	1,879,717	9,595	(d)85	9,960

(a) From official sources. (b) The value of gold is taken at $20.67 per ounce. (c) Not reported. (d) Includes sulphide ore.

SOUTH AMERICA.

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published.

MINERAL AND METAL PRODUCTION OF BOLIVIA. (*a*)
(In metric tons.)

Year.	Antimony. Ore.	Bismuth.		Cobalt. Ore.	Copper. (*c*)	Gold. (*b*)	Silver. (*d*)	Tin. Ore.	Tungsten. Ore.
		Metal	Ore.						
1903......	59	288	....	3.8	4,093	$33,810	39,063	18,425	68
1904......	7	406	....	1.5	3,228	17,130	21,172	20,692	700
1905......	17	592	....	....	6,708	15,044	8,266	26,428	68
1906......	....	231	....	....	4,347	17,403	....	29,374	....
1907......	2,279	249	153,379	....	3,469	3,551	3,696	27,668	....
1908......	734	259	160,305	....	2,878	21,617	4,288	29,938	....

(*a*) From a British Consular report. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and ore. (*d*) Includes ingots, ore and sulphide.

MINERAL EXPORTS OF BRAZIL. (*a*)
(In metric tons or dollars.) (*d*)

Year.	Agate.	Carbonado.	Copper Ore.	Diamonds.	Gold.	Manganese Ore.	Mica and Talc.	Monazite	Platinum. (Grams.)	Precious Stones. (*b*)	Rock Crystal.
1902	81	$49,611	234	$79,071	$636,739	157,295	11.0	1,205	....	$4,332	....
1903	74	66,888	316	62,248	684,389	161,926	7.0	3,299	1,315	8,247	....
1904	54	32,063	610	34,975	611,198	208,260	14.0	4,860	2,122	12,505	35
1905	83	113,157	658	142,459	647,581	224,377	1.0	4,437	72,000	88,463	23
1906	121	319,743	1,484	340,137	771,611	121,331	6,123	4,351	*Nil.*	141,395	37
1907	(*c*)	111,157	(*c*)	33,713	603,640	236,778	4,501	4,438	*Nil.*	33,335	37

(*a*) As reported by the *Brazilian Review.* (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*d*) The par exchange value of the *Mil Reis* in 1907 was $0.546 U. S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103; and in 1907, $3.301

MINERAL PRODUCTION OF CHILE (*a*).
(In metric tons.)

Year.	Borax.	Coal.	Cobalt Ore.	Copper.	Gold, *Kg.*	Guano.	Iodine.	Salt.	Silver, *Kg.*	Sodium Nitrate.	Sulphur
1896	86,892 (*b*)	(*c*)	(*d*)	23,649	1,634	(*f*)	(*e*)	2,434	150,480	1,158,088	940
1897		(*c*)	(*d*)	21,128	1,538	(*f*)	(*e*)	5,867	140,732	1,148,696	664
1898		(*c*)	(*d*)	26,331	2,037	(*f*)	(*e*)	6,684	131,995	1,283,563	1,256
1899		(*c*)	(*d*)	25,719	2,060	(*f*)	274	9,937	129,503	1,389,823	989
1900		(*c*)	(*d*)	25,715	1,975	(*f*)	302	9,879	73,071	1,460,100	2,472
1901		(*c*)	(*d*)	30,155	1,100	(*f*)	269	10,099	70,237	1,273,800	2,516
1902		(*c*)	(*d*)	27,066	1,286	(*f*)	242	9,532	57,418	1,400,408	2,636
1903	16,879	827,112	290	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904	16,733	751,628	125	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905	19,612	793,927	28	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906	28,996	932,488	0.19	25,829	1,135	4,709	331	17,116	21,216	1,822,144	4,598
1907	28,374	832,612	......	28,863	1,907	7,518	4,202	18,982	28,280	1,846,036	2,905
1908	35,039	939,836	......	42,097	1,189	871	330	1,626	52,435	1,970,974	2,705
1909	32,218	898,971	......	42,726	1,268	10,692	474	2,046	44,283	2,101,513	4,508

(*a*) From *Estadistica Minera de Chile.* (*b*) The combined output of the years 1894 to 1902 inclusive. (*c*) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (*d*) The combined output of Chile up to the end of 1902 is estimated at 5941 tons. (*e*) Not reported. (*f*) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons. valued at 5.041,560 pesos ($1.840,169).

MINERAL AND METAL PRODUCTION OF PERU. (a)

(In metric tons.)

Year.	Bismuth.	Borate.	Coal.(b)	Copper.	Gold. Kg.	Lead.	Nickel. Kg.	Petroleum.	Quicksilver. Kg.	Silver. Kg.	Salt.	Sulphur.
1903..	......	2,466	36.920	9,497	1,078.3	1,302	....	37,079	....	170,800	17,637	....
1904..	......	2,675	59,920	9,504	601.4	2,209	....	38,683	....	145.165	18,545	....
1905..	12	1,954	75,338	12,213	776.6	1,476	1,778	49,700	1,554	191,476	21,039	....
1906..	......	2,598	79.969	13,474	1,247.0	2,568	....	70,832	2.304	230,300	20,226	1,830
1907..	48	2,451	185,565	20,681	777.6	5,525	....	100,184	1,500	207,810	21,592	2,030
1908..	9	2,870	311,122	19,854	977.0	2,633	....	125,948	1,822⅔	198.888	21,899	....

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (b) Includes asphaltum and bituminous schist.

SPAIN.

The following tables record the mineral and metal production of Spain, as reported by official authorities:

MINERAL PRODUCTION OF SPAIN. (a)
(In metric tons.)

Year.	Aluminous Earths.	Antimony ore.	Arsenic.	Asphaltum.	Asphalt Rock.	Barytes.	Cement, Hydraulic.	Coal.	
								Anthracite.	Bituminous.
1896	320	54	271	1,285	1,117	345	130,738	14,895	1,852,947
1897	409	354	244	1,878	1,656	429	159,439	8,758	2,010,960
1898	505	130	111	2,354	2,383	364	164,862	20,105	2,414,127
1899	685	50	101	2,646	2,542	887	165,645	34,842	2,565,437
1900	420	30	150	2,331	4,193	833	185,811	68,427	2,514,545
1901	305	10	120	4,182	3,956	1,067	189,909	85,266	2,566,591
1902	337	67	*Nil.*	6,034	6,301	642	201,856	109,298	2,614,010
1903	381	42	1,088	4,675	6,277	507	245,294	108,959	2,587,652
1904	925	245	400	3,463	3,761	453	286,737	163,275	2,903,771
1905	221	77	1,140	5,805	5,725	290	296,605	159,517	2,912,466
1906	386	180	1,114	6,229	7,794	330	299,294	113,747	3,095,043
1907	1,209	205	1,500	8,643	8,219	314	329,926	164,498	3,531,337
1908	60	124	2,004	9,231	12,373	334	343,001	188,463	3,696,653

Year.	Coal (*Continued*).		Coke.	Copper Ore.		Copper.			Fluorspar.
	Lignitic.	Briquets.		Argentiferous.	Pyritic.	Fine.	Matte.	Precipitate.	
1896	55,413	343,432	288,523	(c) 157,365	2,200,919	6	16,378	29,873	3
1897	54,232	332,272	755,394	(c) 18,488	2,161,182	7	16,120	29,652	2
1898	66,422	369,418	768,151	203	2,299,444	593	16,024	29,703	5
1899	70,901	348,838	341,443	1,103	2,443,044	4	15,755	41,927	310
1900	91,133	341,156	381,000	2,006	2,714,714	5	18,159	29,652	4
1901	95,867	338,684	455,586	(b)	2,672,365	79	15,634	28,433	(b)
1902	84,242	331,957	404,503	878	2,617,776	(b)	.....	36,045	93
1903	104,232	339,120	433,780	3,056	2,796,733	(b)	.....	27,448	4,000
1904	100,773	307,630	432,726	(b)	2,624,512	(b)	8,117	29,494	(b)
1905	168,994	290,830	448,073	(b)	2,621,054	(b)	8,243	17,988	(b)
1906	189,048	311,328	435,808	(b)	2,888,778	(b)	9,068	19,200	70
1907	191,001	355,718	476,360	(b)	3,182,645	(b)	9,886	20,887	270
1908	223,160	296,216	477,059	(b)	2,985,779	(b)	205	19,599	253

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous)	
	Argentiferous.	Non-Argentiferous.	Pig.	Wrought Iron.	Iron and Steel Worked.		Ore.	Metal.
1896	3,581	6,762,582	100,786	53,793	68,126	1,240	182,565	84.802
1897	5,559	7,419,768	146,940	80,894	66 007	6,294	186,692	91,258
1898	24,490	7,197,047	113,492	65,900	50,362	5,445	244,068	88,981
1899	17,139	9,397,733	113,071	40,332	112,982	2,790	184,906	70,874
1900	26,348	8,675,749	91,126	54,307	144 355	3,794	182,016	74,341
1901	27.726	7,906,517	135 600	47,085	121,023	2,220	207,188	73,895
1902	24,361	7,904,555	330,747	....	163,564	3,412	227,645	74,370
1903	90,996	8,304,153	380,284	....	199,642	2,578	179,858	56,687
1904	122,109	7,964,748	283,819	50,858	186.705	1,700	177,104	57,956
1905	152,027	9 007,245	305,462	11,366	223,545	720	160,381	56,361
1906	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907	(b)	9,896,178	355,240	14 767	310,125	640	165,289	51,430
1908	(b)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741

Year.	Lead (Non-Argentiferous).		Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrites (Iron).	Pyrites (Arsenical).	Qucksilver.	
	Ore.	Metal.						Ore.	Metal.
1896........	104,160	82,215	38,265	212	770	100,000	(*b*)	34,959	1,524
1897........	110,496	75,112	100,566	200	2,084	100,000	(*b*)	32,378	1,728
1898........	150,472	78,370	102,228	200	4,500	70,265	230	31,361	1 691
1899........	123,753	91,730	104,974	100	3,510	107,386	(*b*)	32,144	1,361
1900........	131,437	98,189	112,897	58	4,170	34,638	515	30,216	1,095
1901........	174,376	95,399	60,325	164	4,220	33,953	1,328	23,367	754
1902........	100,403	103,190	46,069	(*b*)	1,150	145,173	5,648	26,037	1,425
1903........	108,660	118,422	26,194	(*b*)	1,124	155,739	7,996	30,370	968
1904........	93,230	127,906	18,732	(*b*)	3,305	161,841	3,510	27,185	1,130
1905........	105,113	129,332	26,020	(*b*)	1,370	179,079	4,790	26,485	853
1906........	105,095	131,614	62,822	164	1,300	189,243	2,434	28,965	1,568
1907........	103,632	135,066	41,504	114	3,547	225,830	3,423	28,789	1,212
1908........	126,667	134,321	16,745	400	4,483	263,451	5,533	42,210	1,068

Year.	Salt.	Silver.		Soapstone.	Sulphur.		Tin Ore. Dressed.	Topaz. *Kg.*	Tungsten Ore.	Zinc.		
		Ore.	Metal. *Kg.*		Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1896....	521,751	1,230	64,554	750	26,204	1,800	(*e*) 2,348	80	31	64,828	3,485	2,648
1897....	508,606	982	71,168	3,601	18,805	3,500	(*e*) 2,378	44	10	73,848	3,907	2,337
1898....	479,358	967	76,295	2,613	34,943	3,100	4	90	37	99,836	4,300	1,731
1899....	598,108	764	88,409	4,814	58,922	1,100	57	44	151	119,710	4,100	2,084
1900....	450,041	742	140,457	8,109	64,364	750	47	95	1,958	86,158	2,855	2,756
1901....	345,063	391	94,977	4,880	49,856	610	115	310	6	119,708	2,573	2,781
1902....	426,434	175	96,975	542	15,442	450	12,762	*Nil.*	11	127,618	5,569	(*b*)
1903....	427,394	231	112,978	3,725	38,573	1,608	330	90	*Nil.*	154,126	5,134	(*b*)
1904....	543,658	303	117,418	5,165	40,389	605	229	......	60	156,329	5,887	2,913
1905....	493,451	540	123,607	4,364	38,153	610	209	......	375	160,561	6,184	2,936
1906....	541,978	470	126,424	3,609	28,965	700	86	171	430	170,384	6,209	2,639
1907....	605,895	702	127,435	13,875	27,054	3,612	315	266	386	191,853	6,144	2,485
1908....	822,677	441	129,881	4,730	13,872	2,988	838	(*b*)	226	156,233	6,357	2,693

(*a*) Figures are from *Estadistica Minera de España,* except for 1896 and 1898, which were from the official *Reports of the Junta Superior Facultativa de Minas* Madrid. (*b*) Not reported. (*c*) Represents non-argentiferous copper ore. (*e*) U-n dressed tin ore.

SWEDEN.

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN. (*a*)
(In metric tons.)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. *Kg.*
			Ore.	Ingot.	Sulphate.			
1897	131	224,343	25,207	289	1,315	19,298	99	113.3
1898	153	236,277	23,335	235	1,165	20,737	50	125.9
1899	164	239,344	22,334	179	1,287	16,017	35	106.2
1900	167	252,320	22,725	136	1,265	15,228	85	88.5
1901	121	271,509	23,660	137	1,224	13,502	56	62.7
1902	132	304,733	30,095	178	1,257	17,960	63	94.3
1903	140	320,390	36,687	776	1,171	19,392	25	50.6
1904	125	320,984	36,834	533	1,248	18,021	55	60.9
1905	139	322,384	39,255	1,385	1,029	19,224	40	55.0
1906	167	296,980	19,655	1,209	562	21,014	37	20.3
1907	131	305,338	21,957	1,577	782	20,244	33	28.1
1908	138	305,206	21,371	2,808	731	17,494	66	20.3
1909	132	246,808	9,562	2,375	628	15,772	26	14.1

Year.	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms.	Bars, Rods, Sheets, etc.	Iron Sulphate.	Bessemer.	Basic.	Crucible.
1897	2,086,119	538,197	189,633	304,537	232	107,679	165,836	691
1898	2,302,546	531,766	198,923	299,846	124	102,254	160,706	1,013
1899	2,434.606	497,727	195,331	328,999	105	91,898	179,357	1,225
1900	2,607,925	526,868	188,455	324,604	183	91,065	207,418	1,121
1901	2,793,566	528,375	164,850	269,507	140	77,231	190,877	1,088
1902	2,896,208	538,113	186,076	(*b*)	127	84,014	201,311	1,091
1903	3,677,520	506,825	192,342	325,200	62	84,229	232,878	1,105
1904	4,083,945	528,525	189,246	324,676	148	78,577	252,832	1,167
1905	4,364,833	539,437	182,640	356,898	144	78,204	288,675	1,319
1906	4,501,656	604,789	178,298	381,118	170	84,633	311,435	1,457
1907	4,478,917	615,778	174,405	403,994	159	77,036	341,893	1,287
1908	4,712,494	567,821	152,256	363,408	277	81,054	355,394	1,169
1909	3,885,046	444,764	120,669	292,478	182	63,351	248,757	927

Year.	Lead.	Manganese Ore.	Pyrites.	Silver-lead Ore.	Silver. *Kg.*	Sulphur.	Zinc Ore.
1897	1,480	2,749	517	10,068	2,218	(*b*)	56,636
1898	1,559	2,358	386	6,743	2,033	50	61,627
1899	1,606	2,622	150	5,730	2,290	(*b*)	65,159
1900	1,424	2,651	179	5,300	1,927	70	61,044
1901	988	2,271	*Nil.*	11,366	1,557	(*b*)	48,630
1902	843	2,850	*Nil.*	9,378	1,365	74	48,783
1903	678	2,244	7,793	9,792	1.005	(*b*)	62,927
1904	589	2,297	15,957	8,187	651	35	57,634
1905	576	1,992	20,762	8,397	606	....	56,885
1906	753	2,680	21,827	1,938	938	....	52,552
1907	813	4,334	27,113	1,987	929	....	50,884
1908	277	4,616	29,569	2,058	630	....	40,077
1909	166	5,212	16,104	1,721	512	....	43,760

(*a*) From *Bidrag till Sveriges Officiela Statistik Bergshandteringen.* (*b*) Not reported.

MINERAL IMPORTS OF SWEDEN. (*a*)
(In metric tons or dollars; 1 krone=27 cents).

Year.	Asbestos. (*c*)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. *Kg.*	Cement.	Chalk, White, Unground. *Hectoliters.*	Coal.
1896......	116	4,092	298	128	73	4,334	2,901	6,148	1,991,760
1897......	119	5,458	270	175	56	5,549	1,826	14,368	2,240,247
1898......	112	5,409	299	196	75	5,401	1,656	7,016	2,392,451
1899......	567	6,286	292	190	65	4,914	1,363	16,079	3,047,618
1900......	763	5,676	411	194	66	6,084	1,941	12,059	3,033,885
1901......	178	4,524	295	253	68	6,602	2,868	13,569	2,793,309
1902......	213	5,779	....	242	71	7,278	9,822	11,583	2,911,286
1903......	217	5,957	....	240	71	7,419	11,145	41,868	3,192,990
1904......	356	6,243	....	299	77	10,128	10,526	10,115	3,367,826
1905......	140	4,760	264	294	82	18,788	10,999	13,305	3,297,485
1906......	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907......	672	8,213	610	490	85	6,784	17,801	(*g*) 860	4,146,785
1908......	505	6,368	514	347	71	11,499	6,158	(*g*) 419	4,427,507
1909......	383	7,922	529	365	76	10,280	12,944	(*g*) 512	4,084,055

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Iron (crude).	Lead.	Litharge.	Phosphorus. *Kg.*	Platinum. *Kg.*
1896...........	4,037	104	135	4,940	34,549	1,911	150	52,482	34
1897...........	4,944	128	158	7,260	89,606	2,098	199	57,972	63
1898...........	5,227	131	167	7,979	76,832	2,139	160	66,466	49
1899...........	4,740	125	162	6,457	68,909	2,125	177	59,989	99
1900...........	4,745	136	213	6,794	82,957	2,067	148	67,557	59
1901...........	5,153	169	180	6,589	66,131	1,991	165	70,672	172
1902...........	6,890	147	(*b*)	6,754	43,828	2,509	172	68,441	130
1903...........	6,109	132	(*b*)	8,795	49,411	2,644	237	112,659	116
1904...........	7,367	221	(*b*)	8,868	90,102	2,849	213	47,421	84
1905...........	6,481	271	(*b*)	11,270	87,843	2,823	205	69,526	105
1906...........	8,899	284	(*b*)	13,496	108,193	3,457	255	79,048	133
1907...........	(*c*)14,210	336	375	15,037	115,186	3,384	210	77,936	109
1908...........	(*c*)12,276	308	540	11,644	109,841	3,964	248	107,301	117
1909...........	(*c*)10,993	428	443	14,212	99,519	3,222	217	88,241	72

Year.	Potassium.				Quicksilver. *Kg.*	Salt.		Silver.	
	Chloride.	Cyanide *Kg.*	Hydrate.	Carbonate		Crude.	Refined.	Bullion and Mfres. *Kg.*	Specie.
1896..........	241	2,122	285	1,933	5,194	84,629	3,673	7,375	$204,691
1897..........	363	2,922	1,381	1,432	3,125	87,050	3,055	20,557	136,823
1898..........	259	2,604	1,451	1,112	2,631	85,246	2,188	21,696	191,766
1899..........	225	2,313	1,266	1,231	4,210	98,417	3,166	11,565	156,707
1900..........	364	2,221	1,915	1,257	3,629	70,302	3,098	11,559	62,315
1901..........	260	2,658	1,435	1,266	5,958	79,038	3,072	7,476	78,416
1902..........	222	2,950	1,720	1,238	4,866	82,439	3,037	4,853	74,826
1903..........	245	3,294	2,034	1,150	5,043	88,139	3,419	11,259	90,366
1904..........	214	3,237	2,234	1,184	5,768	84,237	4,615	19,034	86,891
1905..........	1,296	3,437	2,251	1,133	4,609	87,677	3,889	11.067	82,620
1906..........	1,986	4,106	2,486	1,082	5,535	88,341	3,700	15,253	93,990
1907..........	1,840	4,150	2,484	1,269	8,930	(*h*) 835,190	18,821	26,334	52,074
1908..........	2,190	3,563	2,835	1,209	7,299	(*h*) 903,633	24,394	20,149	93,669
1909..........	1,809	3,808	2,627	1,312	6,077	(*h*) 766,195	24,143	17,315	154,265

Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		Zinc.
	Carbonate.	Hydrate.	Nitrate. (*d*)	Sulphate. (*e*)			Salts-*Kg.*	Block.	
1896..........	11,425	908	12,518	8,486	11,369	615	4,437	551	2,275
1897..........	14,625	625	12,531	11,384	9,723	1,418	3,823	541	2,551
1898..........	11,917	575	15,419	11,544	10,837	1,742	3,874	595	3,030
1899..........	13,323	929	15,006	15,140	13,505	2,558	5,404	486	2,829
1900..........	12,680	1,038	14,245	15,590	20,152	2,472	3,243	630	2,912
1901..........	13,669	800	17,614	15,494	20,715	1,950	2,334	541	2,900
1902..........	....	1,623	15,553	18,924	23,002	1,887	1,652	644	3.255
1903..........	....	1,426	20,616	16,120	24,577	2,620	1,467	655	3,312
1904..........	11,898	2,112	19,776	17,596	18,248	2,001	1,460	719	3,705
1905..........	13,592	1,489	23,183	17,115	18,631	3,424	1.727	597	3.780
1906..........	14,974	1,478	27,174	19,948	22,745	2,535	2,102	819	4,484
1907..........	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908..........	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909..........	13,490	1,119	28,849	20,226	26,836	1,955	1,357	794	5,294

MINERAL EXPORTS OF SWEDEN. (*a*)
(In metric tons or dollars; 1 krone=27 cents.)

Year.	Alum.	Ammonium Sulphate	Antimony, Crude-*Kg*	Asbestos. *Kg.*	Cement.	Coal.	Copper.		Graphite.
							Ore.	Copper & Alloys.	
1896	40	100	800	2,040	22,991	141	1,094	1,911	4
1897	54	180	800	1,348	27,112	74	(*b*)	933	7
1898	32	36	4,700	1,055	28,676	496	1,102	1,346	9
1899	26	2	2,600	2,812	31,101	762	315	1,230	17
1900	24	2	4,600	2,436	42,564	1,108	448	2,012	18
1901	56	156	1,800	2,179	17,794	716	602	1,243	19
1902	20	174	4,090	1,864	19,499	866	845	1,516	5
1903	22	*Nil*	3,473	15,357	21,319	509	1,555	1,858	9
1904	9	219	3,810	16,339	27,509	605	749	1,396	(*b*)
1905	12	445	3,147	2.386	38,504	425	2,137	2,654	(*b*)
1906	11	30	4,584	1,510	45,960	1,352	1,841	2,662	(*b*)
1907	7	*Nil.*	4,485	2,167	18,053	2,925	882	2,762	8
1908	9	202	4,188	1,335	34,164	1,293	1,114	3,299	18
1909	5	331	6,536	236	33,197	771	723	3,264	7

Year.	Gypsum and Mfres.	Iron and Steel.		Lead and Mfres.	Peat.	Phosphorus. *Kg.*	Potassium Chloride.
		Ore.	Unwrought.				
1896	9	1,150,695	304,138	1,182	1,452	1.510	254
1897	9	1,400,801	279,525	1,473	1,816	1,627	463
1898	27	1,439,860	301,192	570	1,616	4,085	506
1899	8	1,628,011	320,742	818	1,979	1,890	335
1900	10	1,619,902	304,175	1,209	3,843	879	931
1901	55	1,761,257	268,143	1,028	3,064	1,254	708
1902	117	1,729,000	(*f*) 73,403	546	3,620	1,290	1,114
1903	119	2,828,000	(*f*) 70,788	333	3,217	300	790
1904	162	3,065,522	(*f*) 88,124	275	4,212	1,994	1,266
1905	156	3,316,626	(*f*)120.987	512	5,157	34,388	1,499
1906	6	3,661,218	(*f*)112,719	531	6,531	700	(*b*)
1907	16	3,521,717	201,643	519	6,524	(*b*)	(*b*)
1908	37	3,654,268	159,095	496	5,559	400	(*b*)
1909	21	3,204,522	161,757	319	9,999	1,305	3,000

Year.	Salt, Refined *Kg.*	Silver, Bullion. *Kg.*	Soda.	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfres-*Kg.*	Ore.	Crude and Mfrs.
1896	830	819	772	9	18.9	2,996	41,401	184
1897	1,424	329	686	11	25.6	7,113	44,425	135
1898	216	130	509	11	20.8	1,263	49,597	184
1899	110	367	227	68	8.8	1,033	45,634	157
1900	407	296	238	20	21.5	1,521	40,879	156
1901	1,556	179	237	12	20.4	8,110	41,248	101
1902	1,945	110	621	147	25.5	1,603	43,813	63
1903	*Nil*	484	10	217	43.3	3,893	45,389	351
1904	1,883	115	45	4	45.6	3,479	44,259	332
1905	*Nil*	10	403	4	33.9	654	51,765	295
1906	8,652	77	463	12	51.0	353	45,370	410
1907	4,452	160	39	1	67.9	2,518	41,236	528
1908	14,300	136	114	7	53.9	274	38,543	908
1909	6,422	437	27	5	42.5	276	38,865	1,307

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters.

UNITED KINGDOM.

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM. (*a*)
(In metric tons.)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals	Bauxite.	Chalk.	Clay. (*e*)	Coal.
1897..........	621	4,232	13,347	23,087	13,540	3,920,183	12,908,479	205,364,010
1898..........	13,835	4,241	11,272	22,581	12,600	4,366,782	14,974,290	205,287,388
1899..........	5,913	3,890	13,735	25,059	8,137	4,752,982	15,305,895	223,616,279
1900........ :	1,329	4,146	9,727	29,937	5,871	4,444,765	14,279,181	228,772,886
1901..........	4,019	3,416	2,620	26,844	10,357	4,399,043	14,393,196	222,614,981
1902..........	5,755	2,165	842	23,986	9,192	4,466,004	15,549,002	230,728,562
1903..........	3,337	916	58	24,659	6,226	4,541,494	16,460,526	234,019,821
1904..........	6,636	992	44	26,748	8,839	4,509,768	16,210,734	236,130,373
1905..........	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906..........	9,605	1625	650	36,319	6,760	4,825,299	12,459,213	255,067,622
1907..........	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908..........	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909..........	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (*c*)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1897..........	7,470	526	302	4,589	63.2	1,378,496	184,287	7,238
1898..........	9,277	650	57	715	12.3	1,652,701	199,174	5,505
1899..........	8,452	647	796	3,096	103.5	1,800,208	215,974	4,390
1900..........	9,643	777	1,472	21,135	437.6	1,867,211	211,436	4,221
1901..........	6,903	541	4,232	16,641	194.5	1,990,926	204,045	2,649
1902..........	6,210	490	6,388	30,432	130.0	2,100,829	228,264	4,983
1903..........	6,977	545	12,102	29,057	171.0	2,281,689	223,426	4,156
1904..........	5,552	501	18,450	23,574	610.7	2,275,426	237,749	4,616
1905..........	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906..........	7,882	(*b*)	42,521	17,662	(*b*)	2,404,857	228,627	5,512
1907..........	6,867	677	50,257	13,186	59.4	2,438,798	193,297	6,391
1908..........	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909..........	3,777	(*b*)	43,165	5,627	(*b*)	2,199,583	242,832	2,719

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1897..........	14,008,484	4,942,679	35,903	26,988	609	14,653	2,259,325	2,032
1898..........	14,403,769	4,928,347	33,513	25,761	235	20,144	2,172,201	1,575
1899..........	14,692,711	4,992,468	31,494	23,929	422	16,575	2,246,197	1,469
1900..........	14,257,344	4,743,172	32,487	24,762	1,384	15,448	2,318,736	630
1901..........	12,475,700	4,158,745	33,084	20,361	1,673	14,780	2,392,812	71
1902..........	13,641,459	4,470,420	25 000	17,988	1,299	17,235	2,141,355	87
1903..........	13,935,748	4,573,202	26,993	20,278	831	14,377	2,041,851	71
1904..........	13,994,670	4,596,803	26,796	20,155	8,896	16,307	2,370,391	59
1905..........	14,824,183	(*f*) 9,746,221	28,091	20,977	14,582	16,468	2,536,784	*Nil.*
1906..........	15,748,412	(*f*) 9,999,211	30,710	22,693	23,126	14,437	2,586,851	*Nil.*
1907..........	15,983,310	(*f*) 9,850,953	33,053	24,853	16,356	14,927	2,732,968	33
1908..........	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909..........	15,220,408	(*b*)	30,221	(*b*)	2,812	16,575	3,014,678	4

Year.	Pyrites.	Salt.	Silica. (chert and flint.)	Silver. *Kg.*	Stone.			
					Igneous Rock	Limestone.(*d*)	Sandstone.	Slate.
1897	10,752	1,933,949	95,209	7,750	1,876,880	11,179,580	5,043,535	618,941
1898	12,302	1,908,723	83,370	6,575	1,905,830	12,172,267	5,325,988	679,461
1899	12,426	1,945,531	69,955	5,969	4,785,284	12,499,736	5,296,026	650,077
1900	12,484	1,873,601	78,971	5,964	4,709,997	12,099,940	5,101,868	595,428
1901	10,405	1,812,180	132,700	5,452	5,131,787	11,363,202	5,199,234	496,756
1902	9,315	1,893,881	100,938	4,560	5,554,696	12,368,196	5,571,121	525,665
1903	9,794	1,917,274	74,355	5,440	5,512,605	12,419,120	5,496,312	540,143
1904	10,452	1,921,899	66,300	4,967	6,084,642	12,235,825	5,391,265	572,181
1905	12,381	1,920,149	71,808	5,212	6,052,210	12,701,808	5,729,799	523,892
1906	11,318	1,996,593	69,300	(*b*)	6,264,402	12,962,725	5,345,328	500,546
1907	10,358	2,016,409	54,523	4,780	5,765,262	12,709,288	5,092,246	450,651
1908	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909	8,964	1,851,999	53,063	(*b*)	6,384,144	12,000,790	4,673,839	408,639

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore, Dressed.	Block.			Ore.	Spelter.
1897	15,227	7,234	4,524	127	30	18,586	7,162
1898	13,148	7,498	4,722	331	26	23,929	8,711
1899	12,831	6,494	4,077	96	7	23,505	8,837
1900	9,270	6,911	4,337	9	42	25,070	9,214
1901	16,923	7,407	4,634	21	80	23,967	8,555
1902	32,799	7,681	4,462	9	53	25,462	9,275
1903	23,209	7,500	4,351	276	6	25,287	9,430
1904	18,460	6,849	4,198	164	*Nil.*	28,097	10,427
1905	14,523	7,316	4,540	174	105	24,025	9,023
1906	14,338	6,376	(*b*)	267	11	23,189	(*b*)
1907	10,917	7,192	4,478	327	72	20,402	7,222
1908	16,733	8,137	5,133	237	72	15,469	5,926
1909	14,267	8,422	(*b*)	382	6	10,061	(*b*)

(*a*) From *Mineral Statistics of the United Kingdom*. (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*g*) Estimated.

MINERAL IMPORTS OF THE UNITED KINGDOM. (*a*)

(In metric tons or dollars; £1=$5.)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke and Pat.Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1897	11,557	44,541	(*b*)	9,605	83,916	90,008	62,055	6,064,179	(*e*) 160,531	20,735
1898	12,179	46,398	1,255	11,191	91,141	76,201	70,018	5,555,889	(*e*) 162,075	24,619
1899	12,078	59,073	3,076	1,777	130,611	84,015	60,502	7,168,061	(*e*) 174,159	32,427
1900	16,360	53,061	15,667	10,112	102,365	89,123	72,223	6,398,639	178,199	31,687
1901	(*c*) 13,429	74,694	15,710	7,685	102,503	93,338	68,809	5,637,670	198,536	44,721
1902	(*c*) 26,292	65,896	13,390	3,331	90,007	74,684	92,349	6,542,793	226,708	39,584
1903	(*c*) 14,321	(*b*)	11,959	3,535	85,644	77,884	64,591	6,417,188	132,364	17,051
1904	(*c*) 14,325	(*b*)	16,012	2,812	80,771	67,739	90,717	6,198,368	132,494	19,326
1905	(*c*) 16,593	(*b*)	11,552	49,277	94,198	70,235	71,294	7,172,171	128,183	23,569
1906	(*c*) 14,070	(*b*)	16,955	49,269	97,789	76,073	75,487	7,634,839	90,674	36,559
1907	(*c*) 15,579	(*b*)	17,551	19,136	105,409	73,101	89,312	7,764,589	104,950	27,404
1908 (*i*)	(*b*)	(*b*)	(*b*)	3,904	111,897	71,120	124,226	6,154,733	(*b*)	(*b*)

Year.	Iron and Steel. (*Continued.*)								Lead.	
	Puddled and Wrought.	Sheets and Plates.	Rails.	Strips and Wire Rods.	Nails, Screws. Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes Beams Pillars.	Mnfrs. Unenumerated. (*h*)	Ore.	Pig and Sheet.
1897......	(*f*)	(*f*)	(*g*)	(*f*)	(*f*)	40,628	(*g*)	$27,894,295	32,818	170,121
1898......	(*f*)	(*f*)	(*g*)	(*f*)	(*f*)	40,875	(*g*)	33,379,160	44,457	197,591
1899......	(*f*)	(*f*)	(*g*)	(*f*)	(*f*)	78,257	(*g*)	39,527,075	30,263	201,551
1900......	189,891	(*f*)	38,636	(*f*)	(*f*)	182,210	94,667	17,861,660	21,566	198,416
1901......	102,811	(*f*)	55,809	(*f*)	(*f*)	185,810	124,648	18,252,435	29,944	221,549
1902......	178,425	(*f*)	48,942	(*f*)	45,095	285,494	129,743	14,424,835	25,838	235,522
1903......	196,084	73,079	74,939	35,574	51,888	278,441	343,259	9,007,990	18,923	232,939
1904......	109,289	69,552	40,438	38,214	50,649	531,069	219,510	8,630,380	8,748	250,452
1905......	110,576	69,831	34,439	60,318	55,331	613,612	148,995	8,783,895	(*i*) 27,649	233,214
1906......	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	211,577
1907......	83.145	57.280	19,337	56.110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	207,970
1908 (*i*)....	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	23,861	241,320

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1897..........	158,825	412	1,683	39,284	842,920,307	330,335	2,257	16,744	633,009
1898..........	156,390	517	1,398	48,104	829,995,751	334,884	3,389	13,323	665,544
1899..........	261,740	519	6,025	54,712	908,107,248	426,830	5,404	12,635	712,393
1900..........	270,098	469	7,952	50,033	965,167,850	361,309	5,027	12,798	752,605
1901..........	195,736	(*b*)	7,117	42,643	960,650,967	360,568	4,917	12,115	664,041
1902..........	237,066	1,078	6,127	52,023	1,078,095,152	370,697	3,027	11,526	620,948
1903..........	235,574	(*b*)	(*b*)	49,163	1,299,570,625	398,997	(*b*)	9,425	747,714
1904..........	208,458	(*b*)	(*b*)	42,882	1,373,488,176	425,978	(*b*)	12,277	754,722
1905..........	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	709,926
1906..........	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	771,473
1907..........	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	781,486
1908(*i*)........	349,694	(*b*)	(*b*)	(*b*)	1,300,726,576	537,628	(*b*)	(*b*)	771,091

Year.	Quick-silver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.		
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.	Mnfres.
1897..........	1,862	$7,149,210	107,525	22,811	5,345	27,214	25,238	70,929	21,395
1898..........	1,856	5,729,525	132,412	19,642	5,710	20,665	53,945	78,761	21,613
1899..........	1,759	5,162,750	163,387	21,906	6,324	27,608	38,143	71,068	21,521
1900..........	1,113	5,154,430	143,461	22,993	7,449	33,648	42,755	61,504	21,751
1901..........	1,202	5,309,920	108,822	22,440	10,690	35,397	38,660	68,633	21,343
1902..........	1,129	5,383,515	116,791	23,863	12,255	35,713	45,312	89,688	21,717
1903..........	1,187	6,596,045	118,582	21,313	12,473	36,076	41,009	86,539	23,118
1904..........	1,130	8,271,480	122,454	17,629	15,734	39,932	54 438	90,088	22,788
1905..........	1,158	10,426,570	106,107	18,163	(*b*)	40,391	(*i*)23,909	92,261	20,013
1906..........	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*)22.824	95,203	19,664
1907..........	1,341	11,224,650	115.716	15,730	21,205	44,505	(*i*)66,076	90,756	20,163
1908(*i*)........	1,483	10,743,400	(*b*)	(*b*)	25,414	48,496	61,661	91,548	38,717

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*e*) Includes puddled iron. (*f*) Not separately enumerated. (*g*) Returns not available. (*h*) Prior to 1900 many manufactures were not reported separately. (*i*) From *Mines and Quarries.*

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS. (*a*)
(In metric tons or dollars; £1=$5.)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products (c)
1897	(*b*)	398,023	35,919,965	993,980	(*b*)	10,623,050	$8,340,420
1898	(*b*)	331,648	35,619,365	782,053	(*b*)	11,444,431	7,624,740
1899	(*b*)	359,273	41,839,217	881,172	(*b*)	12,422,429	7,712,965
1900	57,478	365,742	46,845,739	1,001,131	(*b*)	11,940,353	9,058,220
1901	46,912	318,216	42,547,114	820,594	1,098,459	13,804,222	5,756,265
1902	40,939	308,104	43,849,591	669,664	1,067,060	15,390,485	5,991,025
1903	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
1904	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
1905	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
1906	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
1907	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
1908(*k*)	(*b*)	(*b*)	63,551,057	1,212,184	1,463,557	19,786,734	(*b*)

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfres.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfres.	Wrought Iron, Shapes and Mfres.
1897	21,252	11,192	15,275	60,326	(*d*)	(*e*)1,219,958	99,259	(*b*)	170,285
1898	27,102	10,452	13,765	52,573	(*d*)	(*e*)1,058,973	86,602	(*b*)	152,911
1899	32,449	7,038	11,231	40,822	(*d*)	(*e*)1,401,365	118,262	(*b*)	161,679
1900	18,300	8,940	10,765	43,601	(*d*)	(*e*)1,450,365	96,567	(*b*)	159,677
1901	26,935	9,252	11,156	36,601	(*d*)	(*e*) 852,609	86,559	(*b*)	119,962
1902	21,658	13,314	14,075	43,995	4,062	1,120,207	104,890	(*b*)	(*b*)
1903	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
1904	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
1905	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
1906	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
1907	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
1908(*k*)	14,869	15,546	19,796	(*b*)	4,478	1,317,330	(*b*)	(*b*)	(*b*)

Year.	Iron. (*Continued.*)								
	Rails.	Wire and Mfres. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc	Steel Shapes, Beams and Pillars.	Total Iron and Steel and Mfres. of.
1897	(*f*)795,983	52,471	120,868	231,319	59,663	276,260	304,249	(*b*)	3,750,122
1898	(*f*)619,976	44,954	102,638	230,219	59,289	255,797	290,182	(*b*)	3,299,326
1899	(*f*)601,266	50,041	111,773	242,167	86,936	260,735	333,837	(*b*)	3,777,098
1900	379,939	39,104	39,157	251,203	66,810	278,338	313,383	(*b*)	3,602,083
1901	474,073	48,107	36,418	254,290	52,217	275,661	217,236	(*b*)	2,944,083
1902	(*b*)	(*b*)	(*b*)	336,572	58,245	317,201	306,152	(*b*)	3,529,223
1903	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159.330	3,621,635
1904	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176.232	3,315,047
1905	555.390	82,519	207,866	413,533	69,937	360,630	8,735	219.491	3,781,059
1906	470,652	96,641	279,459	450,221	66.749	381,421	11,924	311,231	4,763,868
1907	595,272	103,100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
1908(*k*)	589,525	95,801	(*b*)	(*b*)	62,079	409,335	2,452	(*b*)	(*b*)

Year.	Lead. Pig and Mfres.	Salt.	Sodium.				Tin. Block.	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfres.
1897	40,911	680,477	(*g*)252,736	(*h*)	(*h*)	(*h*)	5,050	6,072	6,951	1 047
1898	38,684	698,882	(*g*)191,578	(*h*)	(*h*)	(*h*)	5,557	6,483	7,577	1,227
1899	40,923	638,213	(*g*)193,492	(*h*)	(*h*)	(*h*)	4,785	8,171	5,492	1,249
1900	36,576	556,704	(*g*)185,783	(*h*)	(*h*)	(*h*)	5,713	13,913	7,136	1,159
1901	38,166	627,078	58,412	22,161	50,624	26,057	5,584	13,981	7,512	1,256
1902	33,537	624,752	59,894	24,654	61,658	35,672	6,210	16,717	6,756	1,345
1903	36,152	594,300	58,605	23,574	59,725	45,630	6,349	15,659	8,102	(*i*)
1904	35,600	632,605	61,327	25,252	61,985	40,324	5,953	14,606	7,993	(*i*)
1905	42,265	588,389	67,678	28.425	68,675	33,681	7,741	(*b*)	7,451	(*i*)
1906	45,612	629,658	86,232	26,970	72,218	44,448	8,631	(*b*)	7,962	(*i*)
1907	44,068	592,989	91,120	29,539	70,432	45,898	8,808	11,511	6,666	(*i*)
1908(*k*)	50,221	532,101	(*b*)	(*b*)	(*b*)	(*b*)	9,486	3,833	8,537	(*i*)

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Including naphtha paraffin, paraffin oil and petroleum. (*d*) Previous reports not available. (*e*) Includes puddled iron. (*f*) Includes railroad material of all kinds. (*g*) Includes all soda compounds; not separate; enumerated previous to 1901. (*h*) Included under soda ash. (*i*) Included under spelter. (*k*) From *Mines and Quarries.*

UNITED STATES.

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Statistics of the Department of Commerce and Labor, and special acknowledgment is due to Hon. O. P. Austin, chief of the bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given on an early page in this volume.

IMPORTS. (*a*)

Year.	Aluminum. Crude.				Ammonium Sulphate.			
	Lb.	Kg.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.
1900	256,559	116,374	$44,455	$0.172	24,024,188	10,897	$591,937	$0.025
1901	564,803	251,657	104,168	0.186	31,711,085	14,384	728,085	0.023
1902	745,217	338,028	215,032	0.290	35,535,558	16,119	858,036	0.024
1903	498,655	226,190	139,298	0.279	29,104,817	13,199	765,230	0.026
1904	515,416	234,293	128,350	0.249	39,859,690	18,077	1,058,981	0.027
1905	530,429	240,284	106,108	0.200	15,512,399	7,038	416,048	0.027
1906	770,713	349,195	154,292	0.200	31,797,291	14,423	894,663	0.028
1907	872,474	395,754	181,352	0.208	70,440,992	31,960	1,828,236	0.026
1908	465,317	210,785	80,268	0.173	76,475,104	34,698	1,982,830	0.026
1909	5,109,843	2,317,784	745,963	0.145	85,829,334	38,932	2,114,694	0.024

Year.	Antimony.				Antimony Ore.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.
1900	3,632,843	1,648	$285,749	$0.079	6,035,734	2,738	$78,581	$0.013
1901	3,674,923	1,667	255,346	0.069	1,731,756	786	24,256	0.014
1902	5,742,703	2,605	347,899	0.061	1,639,043	743	29,476	0.018
1903	5,125,515	2,325	279.957	0.054	2,673,142	1,213	51,489	0.019
1904	4,056,299	1,840	235,401	0.058	2,487,602	1,129	50,362	0.020
1905	5,737,891	2,603	431,774	0.075	1,976,694	897	52,868	0.027
1906	7,900,194	3,583	1,417,816	0.179	2,247,131	1,019	128,347	0.057
1907	8,662,683	3,928	1,423,276	0.164	2,780,186	1,261	180,903	0.065
1908	8,114,651	3,954	572,979	0.071	3,280,922	1,488	106,930	0.033
1909	9,557,976	4.335	620,117	0.065	3,471,086	1,575	94,249	0.027

Year.	Asbestos.			Asphaltum.			
	Crude Value.	Mfd. Value.	Total Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	$631,796	$24,155	$655,951	113,557	115,374	$404,921	$3.57
1901	667,087	24,741	691,828	132,079	134,192	516,515	3.85
1902	729,421	33,013	762,434	139,944	142,183	439,570	3.09
1903	657,269	32,058	689,327	167,554	170,235	514,051	3 06
1904	700,572	51,290	751,862	119,575	121,489	510,524	4.27
1905	776,362	70,117	846,479	86,748	88,136	382,667	4.41
1906	536,500	....	....	97.274	98,830	388,010	3.93
1907	1,104,109	200,371	1,304,480	127,902	129,948	518,074	4.05
1908	1,068,342	147,548	1,215,869	131,862	133,971	587,698	4.45
1909	993.254	240.381	1,233,635	132.807	134,939	646,655	4.87

Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900....	(f)	....	....	....	(f)	....	....	......	8,656	8,795	$32,967	$3.81
1901....	(f)	....	....	....	(f)	....	....	......	17,866	18,153	66,107	3.70
1902....	(f)	....	....	....	(f)	....	....	......	15,790	16,043	54,410	3.45
1903....	7,391,566	3,241	$256,097	$0.036	6,344	6,446	$22,777	$3.59	14,889	15,127	49,684	3.34
1904....	6,391,566	2,900	226,481	0.036	6,689	6,796	27,463	4.11	15,475	15,723	49,577	3.20
1905....	6,444,083	2,924	219,198	0.034	7,879	8,005	36,796	4.67	11,726	11,914	46,517	3.96
1906....	7,639,507	3,464	336,609	0.044	4,293	4,362	37,296	8.69	17,809	18,094	63,221	3.55
1907....	9,922,870	4,500	553,440	0.056	28,350	28,804	174,225	6.15	25,065	25,466	93,208	3.72
1908....	9,592,881	4,558	417,137	0.056	(n) 12,196	12,390	58,822	4.83	21,679	22,033	87,823	4.05
1909....	7,183,644	3,259	272,493	0.038	(n) 13,091	13,301	54,707	4.19	18,989	18,689	83,956	4.49

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1900....	132,520,478	60,111	$1,524,205	$0.012	2,386,684	433,037	$3,330,453	$1.40
1901....	120,611,346	54,709	1,673,190	0.014	944,892	170,431	1,305,692	1.38
1902....	112,374,478	50,973	1,456,435	0.013	1,994,790	361,932	2,581,883	1.29
1903....	113,285,240	51,586	912,843	0.008	2,317,951	420,569	3,027,111	1.30
1904....	87,909,168	39,876	707,174	0.008	1,046,404	189,910	1,382,913	1.32
1905....	104,919,462	47,604	843,285	0.008	846,577	153,644	1,102,041	1.30
1906....	105,221,371	47,718	863,490	0.008	2,205,712	400,115	2,950,268	1.33
1907....	112,090,783	50,833	939,248	0.008	2,006,228	363,929	2,637,424	1.31
1908....	74,602,059	33,848	621,713	0.008	839,246	152,313	1,189,560	1.42
1909....	91,390,004	41,454	743,636	0.008	431,785	78,342	642,397	1.49

Year.	Chrome Ore.				Bismuth.				Coal, Anthracite.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1900....	17,572	17,823	$305,001	$17.38	....	....	....	......	118	120	$649	$4.65
1901....	20,112	20,434	363,108	18.04	....	....	....	......	286	291	1,844	6.45
1902....	39,570	40,203	582,597	14.72	....	....	....	......	73,006	74,174	323,517	4.43
1903....	22,932	23,299	302,025	13.17	147,324	66,826	$235,199	$1.59	151,023	153,439	675,623	4.47
1904....	24,227	24,615	348,527	14.38	147,712	67,002	268,837	1.82	72,526	73,686	220,665	3.04
1905....	54,434	55,305	725,301	13.32	148,589	67,459	318,007	2.14	34,262	34,810	107,394	3.13
1906....	43,441	44.136	557,594	12.84	254,733	115,000	318,452	1.25	32,357	32.875	105,190	3.25
1907....	41,999	42,671	491,925	11.71	259,881	117,882	325,015	1.25	9,896	10,054	40,966	4.14
1908....	27,876	28,320	345,960	12.40	164,793	73,002	257,397	1.56	16,483	16,747	73,777	4.47
1909....	39,820	40,459	460,758	11.57	183,413	83,195	286,516	1.56	4,709	4,785	19,438	4.13

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1900....	1,909,258	1,939,806	$5,019,553	$2.63	1,909,366	5,020,102	103,175	104,826	$371,341	$3.60
1901....	1,919,962	1,950,681	5,291,429	2.75	1,920,248	5,293,273	172,729	173,893	266,078	3.67
1902....	2,478,375	2,518,029	7,012,674	2.84	2,551,381	7,339,791	107,437	109,156	423,774	4.05
1903....	3,295,379	3,348,105	9,329,221	2.83	3,446,402	10,004,844	127,479	129,519	437,625	3.43
1904....	1,556,149	1,581,047	3,915,613	2.52	1,628,675	4,136,278	161,476	164,060	648,520	4.01
1905....	1,618,581	1,644,478	3,908,877	2.42	1,652,843	4,016,271	181,376	184,278	796,544	4.39
1906....	1,712,150	1,739,544	4,129,555	2.41	1,744,507	4,234,745	114,703	116,538	558,419	4.87
1907....	2,116,122	2,149,980	5,398,167	2.55	2,126,018	5,439,133	132,536	134,656	594,137	4.48
1908....	1,487,816	1,511,621	4,059,786	2.73	1,504,299	4,133,563	129,591	131,624	603,964	4.65
1909....	1,257,629	1,277,814	3,597,991	2.56	1,262,338	3,617,429	170,671	173,410	735,253	4.31

Year.	Cobalt Oxide.				Copper, Ore and Matte			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1900	54,073	24,527	$88,651	$1.64	54,329	55,201	$5,195,010	$92.23
1901	71,969	32,645	134,208	1.86	96,047	97,584	14,692,645	152.99
1902	79,984	36,281	151,115	1.89	181,566	184,470	8,695,780	47.89
1903	73,350	33,272	145,264	1.98	284,912	289,471	3,177,582	11.15
1904	42,352	19,211	86,925	2.05	268,234	272,527	4,308,410	16.06
1905	70,048	31,802	139,377	1.99	296,251	300,991	5,765,238	19.46
1906	41,084	18,652	83,167	2.02	208,702	212,041	6,795,696	32.56
1907	42,794	19,421	73,028	1.71	291,957	297,096	9,048,270	31.32
1908	1,550	701	3,095	2.00	288,022	292,630	6,978,513	24.20
1909	9,818	4,453	11,065	1.132	393,530	399,846	9,113,254	23.16

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	68,796,808	31,206	$10,557,870	$0.153	5,437	5,524	$72,763	$13.38
1901	73,826,406	33,488	11,812,216	0.160	5,383	5,469	70,886	13.17
1902	103,129,568	46,778	13,051,159	0.126	6,188	6,287	85,640	13.83
1903	136,707,995	62,011	17,262,148	0.126	7,708	7,831	102,879	13.35
1904	142,344,433	64,567	18,374,959	0.129	959	974	13,706	14.30
1905	160,619,385	72,876	22,103,741	0.137	1,600	1,623	22,482	14.05
1906	176,558,390	80,069	30,416,578	0.172	1,505	1,529	29,683	19.72
1907	192,901,267	87,523	38,658,754	0.200	1,438	1,461	28,920	20.10
1908	162,224,144	73,604	22,851,134	0.141	1,124	1,142	16,445	14.63
1909	240,713,721	109,186	30,529,425	0.127	1,278	1,299	18,427	14.42

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value. per L. T.
1900	661,482	300	$26,520	$0.040	11,392	11,574	$202,980	$17.82
1901	1,116,729	506	43,207	0.039	12,441	12,640	240,856	19.35
1902	1,665,737	756	60,079	0.036	7,166	7,281	151,959	21.21
1903	3,595,239	1,630	109,272	0.030	10,885	11,059	188,985	17.36
1904	2,281,193	1,035	109,772	0.048	7,054	7,167	131,493	18.64
1905	3,209,915	1,456	143,729	0.045	11,073	11,250	185,689	16.77
1906	4,655,168	2,113	215,357	0.043	13,840	14,061	286,386	20.69
1907	4,282,228	1,942	186,156	0.043	11,235	11,415	211,184	18.80
1908	1,845,366	838	89,702	0.049	8,077	8,205	145,668	18.05
1909	1,890,010	857	88,782	0.047	10,168	10,331	226,494	22.28

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value. per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	137,086	139,272	$791,189	$5.77	52,565	53,406	$1,907,361	$36.28
1901	175,765	178,577	872,503	4.97	62,930	63,937	1,792,014	28.48
1902	137,386	139,584	646,264	4.70	619,354	629,264	10,935,831	17.66
1903	132,965	134,092	679,112	5.11	599,574	609,167	11,173,302	18.64
1904	130,214	132,297	745,744	5.73	79,590	80,772	1,765,107	22.20
1905	56,021	56,917	273,289	4.88	212,465	215,864	5,185,784	24.41
1906	23,281	23,653	147,547	6.34	379,828	385,905	11,851,210	31.20
1907	25,876	26,290	163,944	6.34	489,475	497,305	13,418,982	27.42
1908	26,734	27,161	175,365	6.56	92,202	93,677	2,886,339	31.35
1909	11,903	12,094	97,277	8.18	174,988	177,797	5,057,039	28.90

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	....	....	$45,703,256	$21,045,828	879,831	893,908	$1,303,196	$1.48
1901	....	....	33,237,629	21,524,251	966,950	982,421	1,659,273	1.72
1902	....	....	22,710,957	21,482,360	1,165,470	1,184,118	2,583,077	2.22
1903	15,267	$120,671	44,054,902	21,212,794	980,440	996,127	2,261,008	2.31
1904	9,126	78,006	75,646,128	9,157,106	487,613	495,415	1,101,384	2.26
1905	13,001	105,997	38,564,328	11,729,077	845,651	859,181	2,062,161	2.44
1906	13,238	108,696	139,705,887	15,873 493	1,060,390	1,077,356	2,967,434	2.80
1907	14,648	122,221	130,605,413	12,792,659	1,229,168	1,248,835	3,937,483	3.20
1908	10,963	92,413	38,346,267	11,930,026	776,898	789,326	2,224,248	2.86
1909	11,406	101,151	30,648 147	13,438,819	1,696,411	1,723,638	4,630,084	2.73

Year.	Scrap, Iron and Steel.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900	34,431	34,982	$663,231	19,685	19,094	$1,058,761
1901	20,130	20,452	339,827	20,792	21,126	1,093,736
1902	109,510	111,262	1,606,720	28,844	29,307	1,286,238
1903	82,921	84,248	1,273,941	43,392	44,090	1,904,469
1904	13,461	13,676	189,506	20,905	21,247	917,254
1905	23,731	24,111	370,328	37,294	37,891	1,522,434
1906	19,091	19,397	248,106	35,793	36,366	1,590,592
1907	27,652	28,094	368,842	39,746	40,382	1,774,441
1908	5,090	5,171	61,981	19,671	19,980	837,585
1909	63,504	64,523	781,426	19,210	19,518	806,862

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900	1,448	1,471	$56,129	165	167	$12,409	12,709	12,913	$1,332,896
1901	1,905	1,935	67,052	2,974	3,021	116,841	8,164	8,295	2,340,112
1902	63,522	64,538	1,576,679	3,362	3,416	131,052	289,318	293,965	7,943,818
1903	95,555	97,083	2,159,273	1,525	1,550	74,898	261,570	265,932	7,331,299
1904	37,776	38,380	808,775	2,135	2,169	60,934	(m) 10,807	10,980	1,537,531
1905	17,278	17,554	409,807	4,772	4,848	137,612	(m) 14,641	14,875	2,072,606
1906	4,943	5,022	137,104	10,231	10,395	256,836	(m) 21,337	21,678	3,010,589
1907	3,752	3,812	104,958	1,508	1,532	82,706	(m) 19,334	19,643	3,004,178
1908	1,719	1,752	53,128	1,110	1,127	75,920	11,212	11,391	1,437,514
1909	1,513	1,537	36,963	(f)	(f)	(f)	19,289	19,599	2,695,630

Year.	Sheet, Plate and Taggers Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900	5,143	5,226	$426,541	60,386	61,356	$4,617,813	21,092	21,430	$1,212,594
1901	5,626	5,716	443,880	77,395	78,638	5,294,789	16,804	17,073	964,744
1902	7,156	7,270	545,739	60,115	61,080	4,023,421	21,382	21,725	1,033,074
1903	11,557	11,741	540,272	47,360	48,118	2,999,252	20,836	21,169	1,028,977
1904	4,165	4,232	302,500	70,652	71,782	4,354,761	15,313	15,558	707,779
1905	2,236	2,272	242,955	65,740	66,792	4,090,523	17,616	17,898	800,027
1906	3,231	3,283	325,276	56,982	57,894	3,883,225	17,799	18,084	876,270
1907	3,749	3,809	367,140	57,773	58,697	4,462,522	17,076	17,349	851,571
1908	2,628	2,669	377,549	58,492	59,426	3,651,576	11,208	11,387	543,170
1909	4,711	4,787	536,841	62,593	63,598	3,782,952	10,544	10,613	531,652

Year.	Wire and Articles Made from. Long Tons.	Metric Tons.	Value.	Total Iron Imports. (e)	Lead in Ore and Base Bullion. Short Tons.	Metric Tons.	Value.
1900......	1,848	1,877	$409,087	$20,443,911	(g) 114,397	103,780	$3,975,695
1901......	4,129	4,192	585,354	20,404,122	111,867	101,486	4,807,762
1902......	3,469	3,525	606,724	41,468,826	105,186	95,425	4,424,511
1903......	5,018	5,098	728,430	41,258,864	103,384	93,790	3,596,635
1904......	3,956	4,019	624,892	21,621,970	104,127	94,464	3,517,691
1905......	3,978	4,042	705,465	26,401,283	92,657	84,081	3,565,282
1906......	6,610	6,716	1,079,868	34,827,132	72,371	65,640	3,490,750
1907......	(f)	(f)	1,551,415	38,789,992	70,538	64,019	3,579,990
1908......	(f)	(f)	1,003,973	19,957,385	109,315	99,168	4,384,904
1909......	(f)	(f)	1,117,812	30,516,536	110,605	100,339	4,121,380

Year.	Lead in Pigs and Old. Short Tons.	Metric Tons.	Value.	Lead, Sheet, Pipe, Shot, Etc. Lb.	Metric Tons.	Value.	Other Lead Mfrcs.	Total Lead.
1900......	....	....	....	27,945	13	$1,393	$5,854	$3,964,942
1901......	604	548	$33,882	56,735	26	2,773	4,654	4,849,071
1902......	2,529	2,294	132,500	224,208	102	7,765	18,918	4,533,694
1903......	3,023	2,742	164,528	17,008	8	810	8,071	3,770,044
1904......	8,724	7,914	461,316	69,581	32	2,441	7,755	3,989,203
1905......	5,720	5,812	367,106	54,779	25	2,638	4,580	3,939,606
1906......	11,763	10,669	910,417	346,177	157	17,250	20,681	4,401,167
1907......	9,277	8,414	846,166	734,418	333	39,210	12,736	4,426,156
1908......	2,759	2,504	182,503	42,376	19	2,026	44,460	4,567,407
1909......	3,576	3,244	230,347	40,434	18	2,056	31,836	4,351,727

Yr.	White Lead. Lb.	Metric Tons.	Value.	Value per Lb.	Litharge. Lb.	Metric Tons.	Value.	Value per Lb.	Red Lead. Lb.	Metric Tons.	Value.	Value per Lb.
1900......	456,872	207	$28,366	$0.062	77,314	35	$2,852	$0.032	549,551	249	$25,532	$0.046
1901......	384,673	174	21,226	0.056	49,306	22	1,873	0.038	485,467	220	19,370	0.040
1902......	506,423	230	25,320	0.050	88,115	40	2,908	0.033	1,075,839	488	37,383	0.035
1903......	453,284	206	24,595	0.054	42,756	19	1,464	0.034	1,152,715	523	40,846	0.035
1904......	587,338	266	33,788	0.058	44,541	20	1,500	0.034	836,077	379	30,115	0.036
1905......	597,510	271	34,722	0.058	117,757	53	4,139	0.035	704,402	320	26,553	0.038
1906......	647,636	294	41,233	0.064	87,230	40	3,737	0.043	1,093,619	497	50,741	0.046
1907......	584,309	265	37,482	0.064	90,475	41	4,386	0.048	679,171	308	35,959	0.053
1908......	540,311	245	30,451	0.056	96,184	44	3,327	0.035	645,073	292	28,155	0.034
1909......	694,599	315	39,963	0.057	90,655	32	3,740	0.041	760,179	345	30,428	0.040

Year.	Orange Mineral. Lb.	Metric Tons.	Value.	Value per Lb.	Magnesite. Long Tons.	Metric Tons.	Value.	Value per L. T.
1900......	1,068,793	485	$61,885	$0.059	....	....	....	....
1901......	977,644	443	52,409	0.053	30,350	30,835	....	....
1902......	997,494	452	49,060	0.049	45,157	45,880	$373,928	8.28
1903......	756,742	343	36,407	0.048	49,684	50,479	461,399	9.29
1904......	766,469	348	37,178	0.049	35,106	35,668	286,828	8.17
1905......	628,003	285	31,106	0.049	66,405	67,566	638,619	9.46
1906......	770,342	350	42,519	0.055	80,711	82,002	863,492	10.70
1907......	615,015	279	37,793	0.061	88,400	89,814	875,359	9.90
1908......	485,407	220	26,645	0.055	75,442	76,648	736,763	9.80
1909......	496,231	225	27,562	0.056	102,045	103,683	985,019	9.66

Year.	Manganese Ore.				Mica.	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1900	256,252	260,352	$2,042,361	$7.97	$319,560	(f)	(f)	......	....
1901	165,720	168,372	1,486,573	8.97	335,054	....	(f)	......	....
1902	235,576	239,345	1,931,282	8.20	466,332	....	(f)	......	....
1903	146,056	148,393	1,278,108	8.75	317,969	$207,954	11,936	16,191	$1,285,935
1904	108,519	110,255	901,592	8.31	269,808	206,021	8,549	8,685	915,470
1905	257,033	261,146	1,952,407	7.60	403,755	335,211	13,451	13,666	1,626,920
1906	221,260	224,800	1,696,043	7.67	1,042,608	86,336	15,156	15,398	1,816,631
1907	209,021	211,236	1,793,143	8.59	915,259	90,153	16,888	17,158	2,153,971
1908	178,203	181,054	1,350,223	7.59	264,755	101,398	16,322	16,582	2,396,217
1909	212,765	216,180	1,405,329	6.60	493,978	104,019	18,578	18,876	2,927,975

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfres.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1900	3,039,094	$274,766	$0.091	9,246	3,450	$1,728,777	$187.00	$36,714
1901	2,294,684	151,913	0.066	7,496	2,797	1,673,713	223.30	24,482
1902	3,578,393	207,310	0.058	8,670	3,235	1,950,362	224.96	37,618
1903	4,266,974	261,199	0.061	9,540	3,561	1,921,772	201.44	1,727,830
1904	4,846,681	277,399	0.057	8,648	3,230	1,812,242	209.55	105,636
1905	13,725,720	672,127	0.049	8,681	3,240	1,985,107	228.67	188,156
1906	21,045,316	1,061,076	0.050	13,928	5,198	3,601,021	258.54	187,639
1907	20,505,197	1,037,728	0.051	7,515	2,805	2,509,926	333.99	175,651
1908	9,289,376	393,050	0.042	4,155	1,551	1,096,615	263.92	134,119
1909	3,862,445	198,540	0.051	9,904	3,696	2,557,574	258.3	410,997

Yr.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1900	1,243,612	68,772	0.055	130,175,481	1,976,604	0.015	111,761	7,758	0.069	10,545,392	276,664	0.026
1901	811,127	61,348	0.076	148,189,337	2,316,577	0.015	430,996	29,224	0.068	9 656,393	253,286	0.026
1902	1,209,148	60,429	0.050	140,980,460	2,141,553	0.015	231,009	15,161	0.066	10,505,474	299,416	0.028
1903	468,042	19,308	0.041	169,337,673	2,550,478	0.015	41,229	2,784	0.067	13,835,668	367,721	0.026
1904	95,889	4,209	0 044	174,865,872	2,832,554	0.016	26,053	1,817	0.069	14,184,287	376,931	0.027
1905	42,510	2,876	0.067	214,207,064	3,326,748	0.016	59,650	4,225	0.070	9,911,534	304,596	0.027
1906	45,873	3,103	0.068	223,203,387	3,858,895	0.017	30,098	2,102	0.080	11,326,256	371,595	0.033
1907	12,980	959	0.074	252,303,441	4,175,353	0.017	18,171	1,307	0.072	18,291,890	574,977	0.031
1908	17,607	1,447	0.082	214,338,887	3,415,326	0.016	216,080	15,453	0.072	16,118,160	470,116	0 029
1909	22,425	1,837	0.082	298,854,649	4,780,106	0.016	640,623	31,798	0.050	28,180,630	764,256	0.027

Year.	Potassium Salts. All Other.		Precious Stones.			Pyrites. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	54,904,088	$1,407,303	$3,751,219	$9,612,127	(f)	332,517	337,837	$1,095,598	$3.30
1901	72,489,913	1,636,856	6,637,860	17,166,049	(f)	398,969	405,353	1,407,244	3.53
1902	91,857,009	1,820,585	8,282,760	18,494,288	(f)	437,319	444,316	1,623,430	3.71
1903	70,205,850	1,593,380	10,374,877	15,428,819	$954,456	427,319	434,156	1,636,450	3.83
1904	74,720,241	1,678,699	10,316,615	16,934,090	803,952	413,585	420,202	1,533,564	3.73
1905	82,935,632	1,891,081	10,203,350	26,699,670	801,566	515,722	520,926	1,780,800	3.47
1906	30,302,735	763,513	11,937,542	32,201,949	988,766	597,347	606,903	2,138,746	3.58
1907	91,299,496	2,220,685	8,740,278	23,706,975	1,069,373	656,479	666,981	2,637,485	4.01
1908	69,382,278	1,721,626	2,367,189	11,660,442	720,502	668 115	678,804	2,624,339	3.93
1909	100,180,417	2,445,526	9,230,287	34,340,269	1,267,457	692,385	703,498	2,428,638	3.51

Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900..........	207,933	188,636	$633,192	$3.05	$14,695,965	$25,404,378	182,108	185,022	$4,935,520	$27.12
1901..........	194,967	176,872	670,648	3.44	12,957,987	18,188,795	208,654	211,992	5,997,595	28.82
1902..........	188,775	167,481	654,990	3.47	8,502,614	17.900,321	205,245	208,529	5,996,205	29.21
1903..........	157,201	142,494	489,179	3.11	7,935,844	16,038,664	272,947	277,314	8,700,806	31.88
1904..........	167,295	151,810	515,822	3.08	11,865,805	14,221,237	228,012	231,660	9,333,613	32.41
1905..........	158,449	143,783	491,079	3.10	16,472,911	19,466,224	321,231	326,371	11,206,548	34.89
1906..........	170,505	154,648	502,583	2.95	20,402,738	23,825,103	372,222	378,178	14,115 206	37.92
1907..........	153,435	139,166	452,227	2.95	17,652,679	28,259,681	364,610	370,444	14,844,675	40.71
1908..........	156.608	142,043	440.484	2.81	14.169,524	28.054.606	310.713	315,684	11,385.393	36.68
1909..........	158,487	143,777	447,983	2.83	15,728,756	30,458,946	422,593	429,376	1,3281,629	31.43

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All Other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1900..........	8,403,749	$150,530	$0.018	73,815,425	$613 379	$0.008	20,484,938	$259,802
1901..........	3,812,847	94,303	0.025	31,415,788	276,261	0.009	14,491,559	189,543
1902..........	3,334,697	77,482	0.020	31,889,252	284,634	0.009	17,151,682	283,745
1903..........	2,970,426	73,647	0.025	25,313,370	228,041	0.009	14,272,646	268,738
1904..........	2,570,984	64,405	0.025	23,631,832	205,496	0.009	10,399,711	281,527
1905..........	2,245,789	56,515	0.025	15,754,979	146,812	0.009	11,257,629	247,413
1906..........	1,209,053	35,262	0.022	6,800,288	71,013	0 010	....	....
1907..........	1,297,070	37,894	0.029	6,198,136	66,521	0.011	8,481,979	258,262
1908..........	874,813	26,079	0.029	3,515,933	38,372	0.011	....	296,777
1909..........	942,982	29,771	0.032	(o) 153,928	3,543	0.023	13,805,869	350,396

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900..........	166,457	169,120	$2,918,610	$17.53	628	638	$17,437	243	247	$ 6,279
1901..........	174,162	176,949	3,256,951	18.70	748	761	20,201	268	272	6,308
1902..........	176,951	179,782	3,360,562	19.00	738	750	19,954	14	15	369
1903..........	188,888	191,910	1,649,756	19.32	1,854	1,883	52,680	189	192	7,254
1904..........	128,885	130,947	2,463,779	19.12	1,332	1,353	39,133	204	207	9,776
1905..........	83,201	84,532	1,522,005	18.29	572	581	16,037	778	709	19,960
1906..........	72,404	73,562	1,282.873	17.72	1,100	1,118	29,565	709	720	17.928
1907..........	20,399	20,725	355,944	17.45	1,458	1,481	41,216	606	616	14,589
1908..........	20,118	20,441	318,577	15.83	793	804	22,562	692	700	17.227
1909..........	26,914	27,346	458,954	17.05	770	782	23,084	966	982	26,021

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1900..........	79	72	$ 1 070	$13.54	69,989,502	31,747	$19,458,586	$0.278
1901..........	2,386	2,164	27,015	11.74	74,560,487	33,820	19,024,761	0.255
1902..........	2,859	2,594	35,336	12.35	85,043,353	38,575	21,263,337	0.250
1903..........	1,790	1,623	19,635	11.00	83,133,847	37,702	22,265,367	0.268
1904..........	3,268	2,964	36,370	11.13	83,168,657	37,718	22,356,896	0.270
1905..........	4,000	3,630	48,225	12.06	89,227,698	40,507	26,316,023	0.294
1906..........	5.643	5,118	67,818	12.02	101,027,188	45,816	37,446,508	0.371
1907..........	10,060	10,221	126,391	12.56	82,548,838	37,436	32,075,091	0.389
1908..........	7,429	6,738	97,296	13.08	82,503,190	37.433	23,932,560	0.290
1909..........	8,377	7,599	102,964	12.29	95,350,020	43,250	27,559,937	0.289

Year.	Zinc.								Mfres.
	Blocks, Pigs and Old.				Oxide. (j)		Sulphide.		
	Lb.	Metric Tons.	Value.	Value. per Lb.	Lb.	Value.	Lb.	Value.	Value
1900......	2,013,196	913	$97,772	$0.048	2,657,514	....	....	....	$36,836
1901......	775,881	352	30,920	0.040	3,327,976	....	....	....	42,643
1902......	1,238,091	561	46,713	0.038	3,434,466	....	1,247,936	$32,879	37,191
1903......	728,614	330	30,900	0.042	3,653,076	$188,495	1,229,806	33,077	18,938
1904......	933,474	423	44,455	0.048	2,809,905	165,110	1,228,875	31,382	11,918
1905......	1,042,081	473	51,052	0.048	3,779,311	196,220	1,235,360	33,308	12,390
1906......	4,407,481	1,999	253,310	0.057	4,494,014	288,065	1,286,469	40,112	17,385
1907......	3,555,890	1,613	210,322	0.059	5,311,318	323,551	1,570,073	51,435	16,282
1908......	1.762,627	799	85.885	0.049	4.635,101	262,876	1,048,109	46,733	7,474
1909......	19.340,029	8,772	826,588	0.043	6,654,352	397,084	1,263,316	44,873	19,176

(a) From Summary of Commerce and Finance of the United States. (b) Includes arsenic sulphide. (c) Barrels of 400 lb. (e) Not including iron ore. (f) Not reported. (g) Includes pig and old. (h) Includes nickel oxide, alloys in which nickel is the principal constituent and manufactures of nickel. (i) Containing more than 25 per cent. sulphur. (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includes bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" steel. (n) Crude.

EXPORTS OF DOMESTIC PRODUCTS. (a)

Year.	Aluminum and Mfres. of.	Asbestos and Mfres. of.	Cement.			
			Bbl. (i)	Metric Tons.	Value.	Value per Bbl.
1900....................	$281,821	$124,971	100,400	18,216	$225,306	$2.24
1901....................	183,579	113,316	373,934	67,393	679,296	1.82
1902....................	116,052	130,437	340,821	61,838	526,471	1.54
1903....................	157,187	158,360	285,463	51,748	433,984	1.52
1904....................	166,876	223,096	774,940	140,898	1,104,086	1.42
1905....................	290,777	....	1,016,236	185,345	1,387,706	1.37
1906....................	364,251	259,760	583,299	105,811	944,886	1.62
1907....................	304,938	200,371	900,550	163,360	1,450,841	1.61
1908....................	330,092	296,890	846,785	153,638	1,249,229	1.47
1909....................	567,375	322,523	1,056,922	191,764	1,417,534	1.34

Year.	Coal.									
	Anthracite.				Bituminous.				Coke.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.
1900..	1,654,610	1,681,084	$7,092,489	$4.29	6,262,909	2,363,631	$14,431,590	$2.31	376,999	$1,358,968
1901..	1,993,307	2,025,200	8,937,147	4.48	5,390,086	3,476.327	13,085,763	2.53	384,330	1,516,898
1902..	907,977	922,505	4,301,946	4.73	5,218,969	5,302,472	13,927,063	2.66	392,491	1,785,188
1903..	2,008,857	2,040,999	9,780,044	4.86	6,303,241	6,404,093	17,410,385	2.76	416,385	2,091,875
1904..	2,228,392	2,264,046	11,077,570	4.97	6,345,126	6,446,648	17,160,538	2.74	523,090	2,311,401
1905..	2,229,983	2,265,663	11,104,654	4.98	6,959,265	7,070,613	17,867,964	2.56	599,054	2,243,010
1906..	2.216,969	2,252.441	10,896,200	4.91	(m) 7,704,850	7,828.128	(k)19,787,459	2.57	765,190	2,758,551
1907..	2,698,072	2,741,241	13,217,985	4.90	(m)10,454,677	10,621,950	(m)26,982,111	2.54	874,689	3,206,793
1908..	2,752,358	2,796,394	13,524,595	4.92	(m) 9,100,819	9,246.431	(m)23,361,914	2.53	620,923	2,161,032
1909..	2,842,714	2,888,340	14,141,468	4.97	(m) 9,693,843	9,849,429	(m)24,300,050	2.51	895,461	3,232,673

Year.	Copper.									
	In Ore and Matte (b).				Ingots, Bars, Plates and Old.				Mfres.	Total Except Ore.
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.	Value.	
1900..	10,007	10,168	$1,332,829	$133.18	337,973,751	153,304	$55,285,047	$0.164	$2,257,563	$57,542,610
1901..	19 613	19,924	2,536,549	129.40	194,249,828	88,111	31,692,563	0.164	1,842,336	33,384,899
1902..	18,035	18,321	1,326,131	73.53	354,668,849	160,876	43,392,800	0.122	2,092,798	45,485,598
1903..	12,291	12,488	855,367	69.59	310,729,524	140,920	41,170,059	0.132	2,339,729	43,509 788
1904..	18,927	19,230	1,202,537	63.54	554,550,030	251,497	71,488,116	0.129	3,328,818	74,816,934
1905..	37 688	38,291	1,531,429	40.63	534,907,619	242,699	80,693,232	0.151	4,184,070	84 890,302
1906..	47,619	48,380	1.760,140	36.96	454,752,018	206,239	84,728,400	0.186	4,284,611	89,013,011
1907..	99,141	100,727	2,452,562	24.74	508,929,401	230,799	94,912,185	0.186	5,888,170	100,800,355
1908..	63.149	64.158	1.254.172	19.87	661.876.127	300,302	87,393,200	0.132	3,162,303	90,555,503
1909..	59,880	60,841	1,335,316	22.29	682,846,726	309,734	89,367,455	0.131	3,217.185	92,584,640

Year.	Gold.		Iron							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value Per L. T.
1900......	$54,064,697	$69,926	51,460	52,283	$154,756	$3.01	286,687	291,404	$4,654,582	$16.23
1901......	56,717,350	1,012,589	64,703	65,748	163,465	2.54	81,211	82,510	1,257,699	15.65
1902......	35,722,835	307,756	88,445	89,860	294,168	3.32	27,487	27,927	502,947	18.30
1903......	43,765,360	581,474	80,611	81,901	255,728	3.17	20,379	20,705	384,334	18.86
1904......	120,226,424	985,403	213,865	217,287	458,823	2.14	49,025	49,809	764,543	15.60
1905......	46,099,580	694,887	208,017	211,345	530,457	2.55	49,221	50,009	762,899	15.50
1906......	46,068,451	640,707	265,240	269,484	771,831	2.91	83,317	84,650	1,506,774	18.08
1907......	54,869,688	345,993	278,208	282,659	763,422	2.74	73,703	74,879	1,508,938	20.43
1908......	80,778,091	437,365	309,099	314,043	1,012,924	3.29	46,696	47,441	789,318	16.92
1909......	132,340,610	540,211	455,934	463,251	1,365,325	2.99	61,999	62,994	1,036,267	16.66

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900......	13,298	13,512	$558,576	$42.04	2,976	3,024	$137,437	107,385	109,103	$2,915,371	$27.15
1901......	17,708	17,993	674,671	38.16	1,561	1,586	74,056	28,614	29,072	708,887	24.78
1902......	22,249	22,605	869,519	39.08	1,674	1,701	82,322	2,409	2,447	74,938	31.11
1903......	19,380	19,690	796,631	41.11	1,241	2,175	101,839	5,445	5,532	141,924	26.07
1904......	29,582	30,055	1,133,128	34.93	3,435	3,489	162,039	314,324	319,353	6,150,035	19.56
1905......	32,025	32,537	1,255,418	39.20	4,426	4,497	182,431	237,738	241,542	4,701,909	19.79
1906......	56,024	56,920	2,575,905	45.98	5,405	5,491	242,776	192,616	195,698	4,094,659	21.26
1907......	24,190	24,577	1,092,631	45.17	8,587	8,724	395,758	79,991	81,271	2,013,319	25.17
1908......	8,224	8,355	362,909	44.12	4,334	4.402	223,073	112,177	113,390	2,674.524	23.84
1909......	13,536	13,755	538,436	39.77	3,856	3,918	200,379	104,862	106,545	2,401,091	22.90

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1900......	25,005,308	11,342	$626,497	$0.025	65,444,387	29,681	$1,816,813	$0.028	9,331	9,481	$600,600
1901......	20,835,944	9,452	450,331	0.021	46,298,262	21,001	1,152 368	0.025	6,909	7,020	452,695
1902......	16,122,775	7,312	339,227	0.021	64,565,650	29,287	1,456,768	0.022	3,434	3,489	229,887
1903......	19,912,563	9,031	424,985	0.021	75,654,532	34,310	1,698,500	0.024	4,782	4,858	273,618
1904......	20,772,049	9,422	416,389	0.020	80,279,746	36,403	1,949,908	0.024	4,728	4,804	247,694
1905......	17,674,099	8,019	352,405	0.020	89,976,088	40,506	2,118,836	0.024	8,004	8,132	460,995
1906......	16,951,893	7,688	340,526	0.020	116,310,428	52,747	2,731,021	0.024	17,054	17,327	1.139,526
1907......	15,521,208	7,042	354,802	0.023	111,670,147	50,642	3,014,863	0.027	40,651	41,301	2,902,025
1908......	15,721,898	7,133	364,202	0.023	71,427,124	32,407	1,813,784	0.025	44,100	44,805	2,985,538
1909......	22,256,458	10,095	456,635	0.021	85,387,006	38,731	1,993,142	0.023	75,305	76,513	4.706,592

Year.	Steel, Sheets and Plates.			Iron Rails.				Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900	45,534	46,264	$1,638,478	5,374	5,460	$119,206	$22.18	356,445	361,945	$10,895,416	$30.58
1901......	23,923	24,303	959,471	901	915	32,357	35.93	318,055	323,044	8,628,781	27.14
1902......	14,866	15,104	725,547	211	214	4.639	22.02	67,455	68,534	1,902,396	28.09
1903......	13,312	13,525	657,713	181	184	8,808	48.67	30,656	31,146	937,779	30.59
1904......	50,477	51,278	2,064,241	1,405	1,427	23,870	17.00	414,845	421,482	10,661,222	25.72
1905......	67,093	68,166	2,889,084	*Nil.*	....	....	....	295,023	299,473	7,310,029	24.78
1906......	93,601	95,099	4,081,915	*Nil.*	....	....	....	328,036	333,285	8,903,411	27.14
1907......	82,045	83,358	4,262,582	*Nil.*	....	....	....	338,906	344,328	10,411,072	30.72
1908......	60,893	61,865	3,422.031	*Nil.*	....	....	....	196,510	199,654	6,021,549	30.62
1909......	104,742	106,423	4,627,614	*Nil.*	....	....	....	299,540	30,435	8,519,793	28.44

Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1900......	67,714	68,797	$3,570,769	$52.73	78,014	79,262	$4,604,047	$59.77	10,652	10,822	$505,529	$47.37
1901......	54,005	54,869	3,031,861	56.10	88,238	89,650	4,805,608	54.36	8,165	8,296	271,552	33.26
1902......	53,859	54,721	2,828,460	52.52	97,843	99,414	5,140,702	52.54	24,613	25,007	831,067	33.76
1903......	30,641	31,131	1,788,556	58.37	108,521	110,258	5,528,726	50.94	22,360	22,718	713,718	31.92
1904......	55,514	56,402	2,777,768	50.04	118,581	120,478	5,935,093	50.05	20,073	20,394	695,448	34.64
1905......	84,234	85,582	4,357,186	51.73	142,601	144,883	7,061,442	49.52	6,514	6,618	277,651	42.62
1906......	112,555	114,356	6,140,861	54.56	174,014	176,798	8,770,042	50.40	5,896	5,990	221,679	37.60
1907......	138,442	140,657	7,784,618	56.23	161,228	163,808	9,164,829	56.84	10,653	10,823	465,757	43.72
1908......	116,878	118,746	6,289,610	53.80	136,167	138,344	7,270,794	53.35	7,412	7,530	277,694	37.39
1909......	90,830	92,288	4,488,197	49.42	149,341	151,738	7,836,564	52.49	20,142	20,465	635,409	31.56

Year.	Lead and Mfres. of.	Nickel. (e)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1900......	$459,574	$1,382,727	138,161	$7,341	$0.053	18,570	$1,681	$0.081	739,163	$54,693	$0.074
1901......	625,234	1,521,291	127,008	6,038	0.050	21,685	1,742	0.079	827,479	53,491	0.065
1902......	696,010	924,579	145,234	6,331	0.042	19,683	1,393	0.071	778,801	49,079	0.063
1903......	491,362	703,550	126,512	6,782	0.054	12,973	1,519	0.118	691,837	51,356	0.074
1904......	616,126	2,130,933	111,176	6,351	0.057	24,989	2,322	0.093	761,358	58,384	0.077
1905......	511,699	2,894.700	126,185	6,086	0.048	28,420	2,215	0.078	881,450	54,901	0.062
1906......	600.057	3,493,643	148,045	7,731	0.052	27,545	2.488	0.090	878,284	54.858	0.063
1907......	686.096	2,845,663	126,306	6,334	0.050	34,625	3,676	0.106	905,924	59,635	0.066
1908......	599,640	3,297,988	149,190	6,520	0.044	43,887	4.543	0.103	1,129,005	75,988	0.067
1909......	509,542	4,101,976	186,305	6,568	0.035	68,759	5,800	0.084	1,046,401	67,814	0.065

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Residue, Etc. (g)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1900......	71,211	$9,933	$0.139	19,750	$845	$0.042	157,108	71.2	$8,186	$0.052
1901......	75,306	10,260	0.136	27,596	1,255	0.046	151,694	68.8	7,960	0.052
1902......	82,201	10,872	0.133	38,316	922	0.024	175,269	79.5	8,398	0.048
1903......	95,622	12,690	0.133	9,753	282	0.029	204,120	92.6	9,596	0.047
1904......	89,738	12,389	0.138	34,904	1,174	0.034	174,582	79.2	8,273	0.047
1905......	113,730	14,312	0.126	70,728	2,128	0.030	160,836	73.0	7,873	0.049
1906......	151,269	18,690	0.124	64,645	1,971	0.030	173,504	72.9	8,463	0.049
1907......	152,029	19,210	0.126	75,775	2,528	0.033	207,504	94.1	10,209	0.049
1908......	147,769	18,971	0.128	77,552	2,793	0.036	141,667	64.2	6,923	0.049
1909......	161,640	20,076	0.124	107,999	3,640	0.034	181,328	82.6	7,609	0.042

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (c)	In Ore (d)
1900......	619,995	629,915	$5,217,560	$8.38	778,191	353	$425,812	$65,705,909	$515,755
1901......	729,539	741,212	5,839,245	8.01	843,938	383	475,609	55,526,975	111,383
1902......	802,086	814,919	6,193,372	7.73	1,013,434	459	575,099	49,228,303	44,651
1903......	785,259	797,823	6,109,230	7.78	1,344,615	610	719,119	40,531,095	79,247
1904......	842,484	855,964	6,521,555	7.74	1,611,365	731	847,108	49,975,370	159,875
1905......	934,940	949,899	7,465,592	7.91	1,009,446	458	497,470	54,133,721	3,379,381
1906......	904,214	918,681	7,373,945	8.16	484,151	219	243,914	57,012,104	266,674
1907......	1,018,212	1,034,503	8,387,176	8.24	384,913	174	192,094	61,202,024	423,842
1908......	1,196,175	1,215,374	9,371,649	7.83	224,692	102	124,960	51,554,414	283,257
1909......	1,020,556	1,036,936	7,644,368	7.49	510,241	231	266,243	56,876,292	716,017

Year.	Zinc Ore.				Zinc Pigs, Bars, Plates and Sheet.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1900	37,555	38,158	$1,133,633	$30.19	44,802,577	20,322	$2,217,693	$0.050
1901	39,425	40,056	1,167,684	29.62	6,780,221	3,071	288,906	0.043
1902	49,762	50,558	1,449,104	29.12	6,473,135	2,936	300,557	0.046
1903	35,188	35,751	987,000	28.05	3,041,911	1,380	163,379	0.053
1904	32,063	32,576	905,782	28.25	20,145,942	9,204	1,094,490	0.053
1905	27,630	28,072	848,451	30.71	11,031,815	5,005	682,254	0.062
1906	24,750	25,146	733,300	29.63	9,340,455	4,236	583,526	0.062
1907	18,171	18,462	579,490	31.89	1,126,753	511	75,194	0.067
1908	23,311	23,683	877,745	37.61	5,280,344	2,396	250,254	0.047
1909	11,121	11,299	412,300	37.01	5,131,360	2,328	263,010	0.051

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1900	11,391,666	5,167	$496,380	$0.044
1901	9,122,283	4,138	393,259	0.043
1902	10,716,364	4,861	433,722	0.040
1903	14,429,885	6 544	578,215	0.041
1904	16,313,826	7,399	628,494	0.039
1905	22,559,625	10,236	810,203	0.036
1906	31,156,616	14,129	1,149,297	0.037
1907	26,512,920	12,023	1,069,924	0.040
1908	24,016,254	10,893	845,070	0.035
1909	29,691,347	13,468	1,026,377	0.035

RE-EXPORTS OF FOREIGN PRODUCTS. (*a*)

Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900	23,520	10.7	$2,352	*Nil.*	....	....	629	639	$10,044
1901	*Nil.*	....	....	25	22.1	$1,536	2,209	2,244	18,078
1902	37,184	16.9	2,710	104	94.6	4,602	2,930	2,977	23,564
1903	79,917	36.0	4,478	*Nil.*	....	....	1,605	1,631	13,894
1904	31,077	14.0	1,734	214	194.0	10,775	1,887	1,917	26,272
1905	*Nil.*	....	....	*Nil.*	....	....	1.081	1,098	18,190
1906	24,892	11.2	4,939	*Nil.*	....	....	1,765	1,793	22,324
1907	47,999	21.8	9,064	6	5	273	8,288	8,421	31,749
1908	1,763	0.8	125	4.8	4.3	663	4,262	4,290	21,419
1909	6,648	3.0	475	0.25	0.23	56	6,867	6,977	48,375

Year.	Cement.			Chemicals.					
				Salts of Potassium. (*f*)			Chloride of Lime.		
	Bbl. (*i*)	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1900	39,540	7,174	$63,880	808,701	366,824	$43,524	148,116	67,185	$1,987
1901	43,691	7,927	72,761	633,100	287,182	43,446	13,916	6,312	312
1902	32,594	5,913	48,797	1,266,145	574,323	59,789	198,794	90,172	2,997
1903	25,362	4,601	32,156	1,299,905	589,637	33,264	836,411	379,696	7,609
1904	39,711	7,186	54,486	1,262,222	572,544	33,358	1,434	650	13
1905	31,874	5,782	40,583	3,053,191	1,386,149	83,652	100	102	3
1906	16,216	2,941	19,487	2,264,175	1,027,935	77,043	*Nil.*	....	....
1907	20,697	3,754	30,435	2,675,248	1,285,892	75,470	*Nil.*	....	....
1908	9,552	1,734	11,455	1,046,689	570,445	34,505	121,511	55,116	912
1909	4,198	762	6,312	2,338,414	1,060,692	66,881	13,964	6,334	292

Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Caustic Soda.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1900....	3,089	3,139	$112,550	1,139,954	517,080	$24,228	78,017	35,388	$1,126	270,307	122,610	$2,788
1901....	2,482	2,519	101,489	1,001,940	452,482	21,511	369,521	167,614	5,184	133,400	60,510	3,398
1902....	3,675	3,734	144,650	1,343,132	609,246	28,704	62,653	28.419	931	115,491	52,386	1,626
1903....	4,417	4,488	184,657	1,116,354	506,378	23,227	30,030	13,622	464	42,540	19,294	437
1904....	6,076	6,173	279,864	1,115,600	506,036	23,608	40.351	18,303	593	1,778,616	806,780	25,312
1905....	8,991	9,135	420,613	1,087,772	493,848	22,728	32.221	14,628	473	16,748	7,604	177
1906....	6,660	6,767	324,915	(*l*)	....	....	2,486	1,128	41	1,032,372	468,180	21,624
1907....	7,159	7,274	370,048	(*l*)	....	....	3,100	1,406	53	742,201	336,662	16,099
1908....	9,955	10,113	514,799	(*l*)	....	....	4,645	2,104	77	834,207	378.726	18,255
1909....	8,233	8,365	377,571	(*l*)	....	....	(*l*)	....	......	1,053,410	477,816	21,777

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old and All Unmanufactured.				
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1900....	6,740	6,848	$19,740	964	979	$170,191	1,281,782	581	$212,264	3	$115
1901....	3,796	4,403	10,627	9,891	10,050	1,406,648	12,888,083	5,846	2,145,468	*Nil.*	....
1902....	7,559	7,680	22,153	14,446	14,657	2,229,912	11,629,877	5,275	1,604,522	12	834
1903....	88,468	89,883	453,613	5,750	5,232	852,726	2.093.103	949	261,413	63	4,223
1904....	7,250	7,366	21,910	*Nil.*	......	....	1,088,672	494	140,695	8	455
1905....	3,945	4,008	10,974	*Nil.*	......	....	1,718,584	780	272,945	5	91
1906....	2,541	2,582	13,062	71	72	29,791	1,567,782	711	309,605	3	362
1907....	1,947	1,978	12,199	....	......	....	995,555	451	199,828	1	41
1908....	4,759	4,832	16,313	2	2	50	718,541	326	93,148	......	....
1909....	3,128	3,178	8,532	434	441	5,600	1,058,528	480	135,952	......	....

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900....	151	153	$6,579	9,079	9,224	$131,241	48	49	$2,447	*Nil.*	....	....
1901....	189	191	6,148	3,331	3,384	51,663	67	68	7,569	*Nil.*	....	....
1902....	250	254	6,286	1,542	1,567	25,020	22	22	1,875	297	302	$7,184
1903....	1,863	1,893	33,996	262	266	2,862	16	16	2,108	739	751	17,560
1904....	1,646	1,672	25,910	190	193	2,367	7	7	765	96	98	2,305
1905....	1,010	1,026	29,047	4,270	4,338	80,623	22	22	2,556	31	31	1,132
1906....	6,750	6,858	236,957	5,111	5,193	101,886	61	62	7,207	*Nil.*	....	....
1907....	2,921	2,968	86,420	157	160	3,378	38	39	3,959	*Nil.*	....	....
1908....	1,827	1,855	52,079	288	293	3,597	26	26	1,271	*Nil.*	....	....
1909....	720	732	25,936	....	......	....	20	20	1,500	*Nil.*	....	....

Year.	Iron and Steel. (*Continued.*)									Lead and Mfres.
	Steel, Ingots, Blooms, Etc.			Sheets, Plates, Rods, Wire.			Tin and Terne Plates, Taggers Tin.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	
1900....	2	2	$1,342	209	213	11,599	464	470	$37,395	$3,843,881
1901....	2	2	1,059	190	193	17,272	118	120	8,519	4,190,525
1902....	106	108	6,774	236	240	14,221	98	100	7,471	3,553,144
1903....	60	61	5,316	55	56	5,532	2	2	184	2,917 957
1904....	40	41	6,208	108	110	6,482	81	82	5,306	2,880,907
1905....	86	87	15,570	161	164	8,019	26	26	3,014	2.441,166
1906 ...	196	199	14,104	318	323	27,631	0.4	0.4	28	2,307,345
1907....	292	297	25,974	14	14	1,220	42.2	42.9	1,813	2,416,082
1908....	33	34	9,822	66	69	3,441	4.7	4.7	351	3,101,953
1909....	60	61	10,389	42	43	2,630	14	14	6,273	3,139,908

Year.	Salt.			Sulphur—Crude.			Tin in Blocks, Pig and Granulated		
	Lb.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1900.......	3,548,724	1,610	$3,907	590	599	$13,495	495	503	$335,377
1901.......	3,699,411	1,678	7,155	207	210	5,086	939	954	562,350
1902.......	2,310,759	1,048	4,544	1,253	1,273	28,024	479	486	286,897
1903.......	7,804,215	3,585	26,636	967	982	22,658	512	520	317,805
1904.......	2,089,234	948	2,814	2,493	2,533	58,887	519	527	322,234
1905.......	611,912	278	893	1,713	1,741	36,858	557	567	375,763
1906.......	1,462,413	663	1,129	403	409	8,475	807	820	650,411
1907.......	1,166,049	529	1,686	301	306	5,759	562	571	492,415
1908.......	2,525,945	1,146	9,352	380	386	8,500	244	248	156,761
1909.......	1,617,705	734	1,700	16	16	284	430	437	282,840

*For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.
(*a*) From Summary of Commerce and Finance of the United States. (*c*) Total exports of coin and bullion; that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate and all other salts of potassium. (*g*) Reported in barrels, but calculated to gallons, on a basis of 42 gallons to the barrel. (*i*) Barrel of 400 ℔. (*l*) Included in all other salts of soda (*m*) Does not include coal used for fuel on vessels for foreign trade.

INDEX